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Title: Disparities in cancer screening in people with mental illness across the world: prevalence and comparative meta-analysis versus the general population including 4,717,839 people

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Background. Since people with mental illness more likely die from cancer, we assessed whether people with mental illness undergo less cancer screening versus the general population.

Methods. Systematic review and meta-analysis of observational studies. Primary outcome was Odds Ratio (OR) of cancer screening in people with mental illness versus the general population. Secondary outcome was prevalence of cancer screening in mental illness. Sensitivity and subgroup analyses considered specific mental illness, diagnostic criteria, confounder adjustment, country/region, and program vs. opportunistic screening. Newcastle-Ottawa Scale was used to assess study quality. This study is registered with PROSPERO, number CRD42018114781.

Findings. Forty-seven publications provided data from 46 samples including 4,717,839 subjects (female=69.85%), for screening for breast (k=35, mental illness=296,699, general population =1,023,288), cervical (k=29, mental illness=295,688, general population =3,540,408), colorectal (k=12, mental illness=153,283, general population =2,228,966), lung (k=1, mental illness=420, general population =0), gastric (k=1, mental illness=420, general population =0), ovarian (k=1, mental illness=37, general population =0) and prostate (k=6, mental illness=52,803, general population =2,038,916) cancer. Median quality of the included studies was high (7; IQR=2).

Considering any mental illness, screening was significantly lower versus general population for any (k=37, OR=0.757,95%CI=0.722-0.792), breast (k=27,OR=0.652,95%CI=0.603-0.705), cervical (k=23,OR=0.891,95%CI=0.840-0.945), and prostate (k=4,OR=0.777,95%CI=0.701-0.862) cancer, but not for colorectal cancer (k=8,OR=1.02,95%CI=0.903-1.151). In schizophrenia, screening was lower versus general population for any, breast, and cervical cancer. In mood disorders, screening was lower versus general population for any and breast cancer, without differences for cervical cancer, while screening was more frequent for colorectal cancer.

In any mental illness, screening prevalence of any, breast, cervical, colorectal, and prostate cancer were 56.5%(95%CI=51.5-61.3%), 61.9%(95%CI=54.7-68.6%), 59.7%(95%CI=49.4-69.2%), 37.1%(95%CI=28.9-46.1%), and 48.2%(95%CI=31.3-65.5%), respectively.

Interpretation. Despite the increased mortality from cancer in mental illness, this population receives inferior cancer screening versus the general population. Specific approaches should be developed to assist people with mental illness to undergo appropriate cancer screening, especially women with schizophrenia.

Funding. None.

Keywords: Mental illness; disparities; cancer screening; gender medicine; prevention, life expectancy.

Research in context

Evidence before this study

People with mental illness have increased cancer mortality than the general population, which is not explained by differences in cancer risk alone. One potential explanation is inferior medical care, especially low rates of cancer screening, which may lead to a later stage cancer diagnosis. We searched PubMed and PsycInfo from database inception up to May 5th, 2019, using the search "(schizophrenia or schizoaffective or psychos* or depress* or bipolar disorder or mania or eating disorder or anorexia nervosa or bulimia nervosa or binge eating disorder or obsessive or compulsive or post-traumatic stress disorder or anxiety disorder or panic disorder) AND (malignancy OR melanoma OR cancer) AND (screening)". We also hand-searched the reference lists of included studies and previous reviews. We included all published observational studies reporting prevalence rates of cancer screening in subjects suffering from mental illness. To date, individual published studies have provided inconsistent results whether there exists an increase, a decrease, or no difference in cancer screening in subjects with mental illness versus the general population. No previous meta-analysis has pooled data on frequencies of any and specific types of cancer screening across all mental illnesses to provide a comprehensive picture of whether and to what degree a disparity exists between subjects with mental illness and the general population.

Added value of this study

This study is the first comprehensive evidence-synthesis to date and provides a quantitative estimate of disparities in cancer screening in people with multiple mental illnesses vs. the general population. Cancer screening is a key component for decreasing cancer mortality. Given that elevated cancer mortality contributes to the 20-year premature mortality among people with mental illness, whether there exists a gap in cancer screening that could represent a modifiable factor is a clinically relevant question.

The present study provides concerning evidence based on data from over 4.5 million people, from all continents except Africa, showing that subjects (women in particular) experiencing mental illness (schizophrenia in particular) undergo less cancer screening than the general population, after accounting for several confounding factors. Our subgroup analyses shed further light on the specifics of these disparities, showing that disparities occur across countries, but that the extent of such disparities between countries may be different, and that they are particularly pronounced for women with schizophrenia. However, even subjects with mood disorders, conditions that are far more frequent than schizophrenia, suffer from significant cancer screening disparities. Also, we show that the gap is largest where the healthcare has improved the most for the general population, namely in program vs. opportunistic cancer screening. Finally, we show that Asia is the region where the lowest portion of subjects with mental illness undergoes cancer screening, and conversely that Australia is the region where the healthcare system works the best in involving subjects with mental illness in cancer screening.

Implications of all the available evidence

The evidence synthesis provided by this study illustrates consistently inferior cancer screening across mental disorders, which calls for urgent actions to promote cancer screening in subjects suffering from mental illness, and in women in particular, in virtually all regions around the world. Cancer screening programs that have shown to be effective in the general population do not appear to work for as well for people with mental illness, and specific as well as tailored interventions are urgently needed. Primary care and prevention service stakeholders, general practitioners, and psychiatrists should fill this gap in health system organizations and everyday clinical practice. Future, large-scale, multi-center prospective studies should identify what interventions and care structures are most effective and cost-efficient for providing adequate cancer screening to people with mental illness, and investigate how this may improve overall health outcomes and life expectancy among this vulnerable population.

Introduction

People with mental illness die around 15-20 years earlier than the general population, primarily due to physical health conditions (1-3). The disparities in physical health between those with mental illness and the general population is increasing over time, and those with mental illness are seemingly not benefitting from the improvements in health outcomes seen in the general population (1). Cardiovascular diseases are the most common cause of death with a two- to three-fold increase in standardized mortality ratios (4, 5), together with several frequent comorbidities, such as osteoporosis, metabolic syndrome and diabetes (6-8).

In addition to the aforementioned comorbid conditions, cancer is also responsible for increased mortality in mental illness. While the overall incidence of cancer in mental illness is similar to the general population (9), mortality from cancer in both genders is increased 1.4- to 2- fold (4). The incidence of cervical cancer has been reported as slightly less than that in the general population (10) but mortality rates are higher, with a high case fatality ratio for women with cervical (1.98, 95% confidence interval [CI] 1.31-2.92) or breast cancer (1.23, 95% CI 1.01-1.51) and an overall cancer mortality rate ratio in women with mental illness of 1.24 (95% CI 1.17-1.32) (11). Original studies have also described increased mortality in colorectal cancer (12).

Several reasons could explain why cancer mortality differs between subjects with and without mental illness. For instance, increased cancer mortality in mental illness may be due to disparities in care (13), in that people with mental illness are significantly less likely to receive surgical interventions or radiotherapy and to have fewer chemotherapy sessions (10). Additionally, it has been suggested that those with mental illness may be less tolerant of intensive treatment regimens with significant side effect burdens and also that co-morbid physical illness may contribute to the increased mortality rates (14). Another potential explanation, however, is that increased cancer mortality in mental illness may be due to delayed cancer diagnosis (i.e., detection at an advanced stage when the prognosis is already poor) (15).

Despite the fact that few studies have questioned a delayed cancer diagnosis in mental illness(16), others have shown that later stage at diagnosis, including presentation with metastases, is one of the main factors explaining increased cancer mortality in subjects with mental illness compared with non-users of mental health services.(10, 12) Also, previous systematic reviews have suggested that the quality of all preventive services for those with mental illnessis of lower quality (17). Additionally, both narrative reviews and meta-analyses in women with mental illness have shown substantial disparities in cancer screening compared to the general population (18, 19), although only examining female samples, specifically with relation to breast cancer. Thus, there is currently little understanding of the extent to which these disparities persist across sexes and cancer types. Furthermore, the differences in cancer screening between diagnostic categories of mental illness, and across nations, regions and related health care systems, deserve further exploration.

Therefore, in order to provide an updated understanding of how disparities in cancer screening may affect people with mental illness, we conducted a systematic review and meta-analysis investigating screening rates across all cancers in subjects with mental illness. We further sought to conduct subgroup analyses to examine differences with regards to cancer screening types, sex, region, and psychiatric diagnoses. We hypothesized that subjects with mental illness would be disadvantaged in cancer screening compared with the general population, that such disparities are most pronounced in people with schizophrenia, but also in patients with mood disorders. Furthermore, we hypothesized that cancer disparities would be relatively universal across all types of cancer, and across all regions.

Methods

Search, inclusion criteria

We followed an a-priori protocol registered in PROSPERO, CRD42018114781. We complied with the procedures outlined by the 2015 update of the Preferred Reporting Items for Systematic review and Meta-Analysis Protocols (PRISMA-P) (http://www.prisma-statement.org/) (20) and the Meta-analysis Of Observational Studies in Epidemiology (MOOSE) guidelines (21), performing an electronic literature search from database inception and without language restriction on May 5th, 2019, using PubMed and PsycInfo. The following search key was used in PubMed, with equivalent/appropriate syntax for PsycInfo "((schizophrenia or schizoaffective or psychos* or depress* or bipolar disorder or mania or eating disorder or anorexia nervosa or bulimia nervosa or binge eating disorder or obsessive or compulsive or post-traumatic stress disorder or anxiety disorder or panic disorder) and (melanoma or malignancy or cancer) and (screening)". In addition to systematic database searches, references of previous reviews on this topic and of included studies were hand-searched for potential additional eligible studies.

Inclusion criteria were: i) observational studies, ii) focusing on any type of cancer screening, iii) in patients with mental illness, defined according to structured criteria, validated scale, or clinical records, and iv) which reported prevalence of cancer screening in patients, or comparative measures between patients and the general population. No restriction was applied to mental illness or cancer type.

Couples of two authors (EF, MF, ED, JF, AK, AM, BS, JS) independently conducted the search and selected eligible papers. Any disagreement was resolved by consensus by a third author (MS).

Data extraction

The following information was extracted into a pre-defined excel spreadsheet. Author, year, diagnostic criteria, specific mental illness, age range of the population, number of patients, number of controls, total population, country, type of cancer participants were screened for, percent females, whether association measures were adjusted or not, which variables the association measures were adjusted for, the percentage or raw number of subjects receiving cancer screening in patients and in controls, and - if available - adjusted association measures quantifying eventual disparities in cancer screening between mental illness patients and controls (OR, RR, together with 95% confidence intervals). Two authors (MS, EF) independently extracted data. Any disagreement was resolved by consensus. No language restriction was applied.

Quality assessment

Two authors (MS, ED) independently assessed the quality of the included studies with the Newcastle-Ottawa Scale (NOS), with a score $\geq$7 (out of 9) indicating high quality (22).

Meta-analysis

Given that we anticipated considerable heterogeneity across included studies, we performed a random-effects meta-analysis (23, 24) using comprehensive meta-analysis (CMA, version 2). We calculated the odds ratio (OR) and 95% CI of any and specific cancer screening in patients with mental illness versus the general population (primary outcome), and the pooled prevalence of cancer screening in patients together with its 95%CI (secondary outcome). Heterogeneity was assessed with the I^2 statistics for each analysis (with significant heterogeneity being indicated by $I^2 \geq 50\%$ (25). Publication bias was assessed via visual inspection of funnel plots and the Begg-Mazumdar Kendall's tau and Egger bias test (26). We also calculated the trim and fill adjusted analysis (27) in case of publication bias (namely Egger's test p-value <0.1), and the fail-safe number (estimated number of studies needed to move the effect size from significant to non-significant).

We also ran sensitivity analyses considering only studies, which defined mental illness according to any version of the DSM or ICD-criteria, and in studies adjusting for confounding factors.

Also, we ran subgroup analyses comparing cancer screening disparities and prevalence in patients with schizophrenia versus patients with mood disorders, comparing studies from different regions, and comparing cancer screening usually implemented in the context of screening programs, based on the available quantitative evidence (breast and cervical) vs. other/opportunistic cancer screening (colon, prostate). Given the different health care system between Canada and United States of America (national health service versus. insurance-based service), we did not pool the two countries together in the "North America" region, but analyzed them separately instead.

Finally, we run random effect meta-regression to test whether and quantify how the gap between subjects with mental illness and the general population increased with increasing screening rates in the general population.

Results

Search results and the study selection process are described in Figure 1. Out of 3,710 initial hits, we screened 3,004 studies at the title/abstract level, selecting 145 studies for full-text assessment. We excluded 98 studies for specific reasons after full-text assessment, and finally included data from 46 samples (reported in 47 publications). The complete list of the 98 studies excluded after full-text assessment, with reasons for exclusion, is reported in Supplementary material, page 17.

Detailed characteristics and references of included studies are reported in Supplementary material, page 2. Overall, this meta-analysis reports data from 4,717,839 subjects (501,559 patients with mental illness, and 4,216,280 controls), who were more than two-thirds female (69.85%). Mental illness was defined in 20 studies according to DSM or ICD diagnostic criteria, 13 with validated scales, 10 according to clinical records, and 3 using different criteria within the same study. The cancer screening period lasted from 1 year (7 studies) to lifetime screening (6 studies). Age ranged from 18-79 years. Concerning mental illness, 14 studies focused on subjects with depression only, 6 with schizophrenia, 14 with mixed mental disorders while reporting screening estimates for specific groups, and 12 included mixed mental disorders without reporting on specific diagnostic groups. All continents except Africa were represented. Specifically, 25 studies were conducted in the USA, 5 in Canada, 3 in the UK, 3 in Australia, 2 in Israel, 2 in Denmark, and one each in Taiwan, Hong Kong, in the European Union (without specifying countries), in Sweden, Japan, and in the USA plus Canada. Overall, 31 studies provided adjusted estimates, while 15 did not consider the influence of confounding factors. Confounding factors considered in the analyses heterogeneously included social, economic, demographic, behavioral, and clinical factors potentially influencing the association between mental illness and low cancer screening. A detailed report on the quality of included studies according to the NOS scale is reported in Supplementary material, page 13. The quality of included studies was high (NOS score $\geq$7) in 26 out of 46 (56.52%) studies, with a median=7 (IQR = 2).

Results of main comparative random-effects meta-analysis together with publication bias, fail-safe number and trim and fill analysis are reported in detail in Table 1. A forest plot is also represented in Figure 2, showing disparities in cancer screening between mental illness and the general population in any, breast, cervical and colorectal cancer.

Screening occurred in significantly fewer people with mental illness than in controls for any (k=37, OR = 0.76, 95%CI 0.72-0.79, p<0.001), breast (k=27, OR = 0.65, 95%CI 0.60-0.70, p<0.001), cervical (k=23, OR = 0.89, 95%CI 0.84-0.94, p<0.001), and prostate cancer (k=4, OR = 0.78, 95%CI 0.70-0.86, p<0.001), but not for colorectal cancer. In schizophrenia, screening was significantly less likely than controls for any, breast, and cervical cancer. In mood disorders, screening was significantly less likely than in controls for any

and breast cancer, without any difference for cervical cancer, while screening was more frequent than in controls for colorectal cancer.
Publication bias emerged only for any cancer screening in any mental illness (one out of 12 comparisons, with fail-safe N equal to 3,117). The trim and fill analysis confirmed that subjects with any mental illness are significantly less likely to receive any cancer screening even when adjusting for indicated publication bias.

Results of comparative sensitivity random-effects meta-analysis together with publication bias, fail-safe number, and trim and fill analyses are reported in detail in Table 1 (together with main analyses).
Considering studies using DSM/ICD criteria, compared with the general population, any cancer screening was significantly less likely in any mental illness and in schizophrenia, but not in mood disorders. In patients with any mental illness, schizophrenia, and mood disorders, breast cancer screening rates were the lowest versus the control group compared to all other examined cancers. Prostate cancer screening was also significantly less likely in any mental illness compared with the general population. Conversely, cervical cancer screening rates were not different from the general population in any mental illness, schizophrenia, or mood disorders. Similarly, colorectal cancer screening rates were not different between any mental illness and controls.
Publication bias emerged in four out of 11 comparisons, and results remained significant after a trim and fill analyses.

In studies adjusting for confounding factors, any cancer and breast cancer screening rates were significantly lower versus controls in subjects with any mental illness, schizophrenia, and mood disorders. Cervical cancer screening was less frequent in any mental illness, and schizophrenia compared with controls, but no difference emerged for mood disorders when considering adjusted studies only. Prostate cancer screening rates were lower in any mental illness compared with controls in adjusted studies. Finally, in adjusted studies, colorectal cancer screening did not differ significantly between subjects with any mental illness, or mood disorders, and controls.

Publication bias emerged in three out of 12 comparisons and results remained significant after a trim and fill analyses, with fail-safe numbers ranging from 136 to 7,862 (see Table 1).

Detailed results of subgroup analyses of country/region, diagnostic spectrum, and program versus opportunistic screening, with heterogeneity measures, are reported in Table 2 and Table 3. In regional subgroup analyses, considering any mental illness, no significant differences emerged in terms of disparities in any site cancer screening. When looking at specific cancer sites, differences across countries emerged for breast, cervical, colorectal, and prostate cancer. However, disparities were confirmed in the vast majority of countries. Conversely, any cancer but not site-specific cancer screening disparities differed among regions in schizophrenia and mood disorders (See table 2 and table 3).

In diagnostic spectrum subgroup analyses, any site and breast cancer screening disparities differed between schizophrenia and mood disorders, being consistently lower in schizophrenia. On the other hand, cervical screening disparities did not differ between schizophrenia spectrum and mood disorders.

Finally, disparities in cancer screening were more pronounced in the context of screening programs compared with opportunistic screening.

Detailed results of the prevalence of cancer screening analyses are reported in Table 4. In any mental illness, screening prevalence of any site, breast, cervical, colorectal, and prostate cancer were 56.5% (95%CI=51.5-61.3%), 61.9% (95%CI=54.7-68.6%), 59.7% (95%CI=49.4-69.2%), 37.1% (95%CI=28.9-46.1%), 48.2% (95%CI=31.3-65.5%) respectively, and no differences emerged between people with schizophrenia and mood disorders. Conversely, large regional differences emerged in cancer screening prevalence for all aforementioned cancer sites, with Asia consistently having the lowest prevalence of cancer screening, Europe, Canada and USA being overall in the middle, and Australia providing the highest rates of cancer screening in subjects with mental illness.

Results of meta-regression are reported in Table 5. Result show that considering any cancer, cervical cancer, and colorectal cancer, the gap between subjects with mental illness and the general population increases with increasing participation of the general population in cancer screening ($p<0.001$ in each group).

Discussion

The current meta-analysis is the first investigating any and specific cancer screening rates among people with any mental illness, including data from over 4.5 million subjects from all parts of the world, except Africa. Results indicate that subjects with mental illness experience disparities in any, breast, cervical and prostate cancer screening compared with the general population, particularly for breast cancer and in females with schizophrenia. Disparities are also apparent across different regions of the world but to a different extent. Given that cancer screening protects from cancer mortality (70% decline in cervical cancer mortality since screening introduction)(28), such disparities may lead to increased cancer mortality in subjects with mental illness.

The results of our meta-analysis extend previous narrative reviews and confirm our hypothesis that subjects with mental illness undergo less cancer screening than the general population. Results are in line with Aggarwal et al. (studies=19, participants=106,905) (18), Lord et al. (studies=19 in total, 18 for mammography, 10 for uterine cance screening, 4 for colonoscopy, participants=1,377,147) (17), and the meta-analysis of breast cancer screening (mammography) by Mitchell et al. (studies=24, participants=715,705) (19), as well as previous studies, which showed an association between psychotic disorder, substance abuse, and utilization of primary/non-psychiatric care.(29) The present data however expand aforementioned previous systematic reviews, including any mental illness and any cancer type in one quantitative evidence synthesis. The underlying reasons that may explain disparities in cancer screening are multiple. First, while many psychiatrists believe that physical examinations should not be performed by other

professionals (30), they rarely perform physical examinations themselves, possibly due to a shortage of time and equipment, due to challenges associated with agitated or uncooperative patients, and, possibly, due to a degree of skill atrophy, especially in more senior psychiatrists (31). Rare physical examination performed by psychiatrists may reflect poor attention to physical health. Second, it has been shown that a negative attitude of general practitioners towards cancer screening is associated with an almost 20% increased likelihood of patients' not undergoing cancer screening procedures (32). If general practitioners have negative attitudes towards mental illness, this may also partly explain our findings. Third, nurses, who have a positive attitude towards promoting physical health in subjects with mental illness, have shown to be more ambivalent when it comes to cancer screening (33). Such ambivalence may be due to lack of training on physical health promotion, and lack of communication between primary and secondary health-care systems (34). Fourth, symptoms and impairment in (social) functioning and in cognition may compromise healthcare access and utilization. Fifth, the lower cancer screening rates in mental illness may also be explained by common risk factors for mental illness, cancer and a reduced likelihood of undergoing cancer screening. Specifically, poverty and low socio-economic status (SES) are known risk factors for psychiatric disorders (35), while women with lower educational level and lower SES have also been reported to know less about cervical cancer and screening (36). Sixth, patients with mental illness may have difficulties in communicating somatic symptoms, or could not be interested in doing so due to depressed mood or negative symptoms. Seventh, while a call for optimizing the synergy between mental health and primary care has been raised by the World Health Organization,(37) and consistently by other authors,(38-40), this strong rationale has only insufficiently translated into any actual change in clinical practice yet. Finally, diagnostic overshadowing, namely clinicians' attributing early somatic symptoms of cancer to underlying mental illness, may also explain why patients with mental illness undergo less medical exams (41).

We also confirmed the hypothesis that subjects with schizophrenia would suffer from more pronounced disparities compared to individuals with mood disorders. Such differences may be due to the persistent functional impairment, which is more frequently present in schizophrenia (42), as opposed to more frequent, yet still often sub-optimal inter-episode improvement of functioning in people with mood disorders (43). Thus, impairment in social functioning, which is closely related to (social) cognition in schizophrenia (44), may be responsible for less effective memory, more severe social withdrawal, less medical care help seeking behavior, and less social contacts, which each contribute to less participation in cancer screening. Nonetheless, we have also shown that any and breast cancer screening is low in people with mood disorders, hence raising public health concerns given the high prevalence of mood disorders compared with schizophrenia.

We also confirmed that cancer screening disparities were universal across different geographical regions, yet to a different extent. Region-wise subgroup analyses showed that the lowest prevalence of cancer screening in subjects with mental illness is found in Asia, and the highest in Australia, with Europe, USA and other regions ranging between these two extremes. However, paradoxically, Australia also had the highest disparities for some cancer sites, and in people with mood disorders in particular (see table 3). This result can

be explained by the fact that disparities are largest where screening in the general population is the highest, as shown by the meta-regression analyses. In other words, if in Australia cancer screening campaigns work brilliantly for the general population, this does not hold true for patients with mental illness, who do not benefit as much from health-care progress as the general population. Differences among regions may also be due to variable measurements healthcare system properties, or cohort-level characteristics.

Despite confirming most of our hypotheses, colorectal cancer screening did not differ between mental illness and controls, although the colorectal cancer screening prevalence was the lowest (37.1% versus 48.2%-61.9% for the other cancer sites). This finding indicates that cancer screening rate disparities also depend on the rates of cancer screening in the general population. For instance, when the general population suffers from low cancer screening coverage (45-47), disparities for the mentally ill might not be evident due to a ceiling effect.

The present work has several implications, given that cancer screening disparities are highest for those cancers where universal programs usually exist around the world (i.e., breast, cervical), compared with other cancer sites (i.e., colon), for which opportunistic screening procedures are performed. In other words, while cancer screening campaigns work well in preventing cancer in the general population in several countries with national screening programmes, such as in the UK, Italy, and Sweden, among others, apparently this benefit does not generalize to people with mental illness. For instance, while a meta-analysis from 2001 (48) showed that more women who received a reminder letter attended cancer screening (OR=1.64, 95% CI=1.49-1.80), and while other strategies seem to promote cancer screening in the general population, (49-52) approaches generally working with subjects not affected by mental illness might not work for subjects with mental illness. Therefore, such interventions should likely involve awareness among mental health specialists, and facilitation of communication between primary and tertiary care as well as between specialists in mental health and physical health care, aiming for a close collaborations between mental health and primary care.(37-40, 53)

The present work has several limitations. First, results were virtually always heterogeneous, calling for cautious interpretations, especially of some of the marginally significant findings. More specifically, the studies included in the present meta-analysis reported on studies from countries with different screening guidelines and with different follow-up durations. Second, in subgroup analyses, some regions were under-represented (i.e., Asia versus USA). Hence, results on differences among these under-represented countries and others should be considered exploratory. Third, we relied on published data and were only able to report results that were adjusted for a limited number of potential confounders, namely those that the authors of the original papers had adjusted their analyses for. Furthermore, based on the more limited data, there remains controversy about the value of screening for prostate cancer (54). However, prostate cancer screening was included in our analyses, as reduced uptake in people with mental illness may serve as a marker of reduced access to preventive care in general. By definition, our results only apply to cancer sites for which widespread screening exists. Due to very limited data on lung cancer, despite high smoking frequencies in

the mentally ill (55, 56), our results cannot explain disparities in survival for lung cancer (or other cancers), yet, likely similar barriers to screening and health care access and quality for mental illness will be at play there too. Furthermore, since too few studies were available that differentiated between unipolar vs bipolar mood disorder, we were unable to conduct subgroup analyses of cancer screening across these two subgroups. Additionally, studies adjusting for potentially confounding factors considered heterogeneous types and numbers of covariates. Finally, we did not find any studies on melanoma, although screening for this cancer is common in several countries, including Australia.

In conclusion, subjects with mental illness, including mood disorders, and in particular women with schizophrenia, undergo cancer screening significantly less frequently compared with the general population. Such a gap is most pronounced for those cancers for which the general population often receives universal screening based on national programs. Such disparity may contribute to the life expectancy gap between subjects with psychiatric disorders and the general population. Asia has the lowest screening rates, and Australia has the highest, and disparities seem to be the highest where the general population is best involved in cancer screening programs. More studies are needed on lung cancer screening, given the high rates of smoking in people with mental illness. Specific strategies, which should ideally involve mental health departments, general practitioners, and prevention as well as primary care departments, should be tested and implemented in order to fill this important health care gap and to avoid subjects with mental illness being left behind in cancer prevention.

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Authors' contributions

MS and BS designed the protocol of the study. MS, EF, AK, JF, MF, ED, AM, JIS, BS conducted the screening and data extraction. MS, CUC run the analyses. MS, AFC, PFP, SK, CUC drafted the manuscript. All authors read, modified, and approved the final version of the submitted manuscript.

Conflict of interest statements

Authors declare no conflict of interest

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Ethics committee approval

No ethical committee was necessary for this meta-analysis.

References

1. Saha S, Chant D, McGrath J. A systematic review of mortality in schizophrenia: is the differential mortality gap worsening over time? Archives of general psychiatry. 2007;64(10):1123-31.
2. Thornicroft G. Physical health disparities and mental illness: the scandal of premature mortality. The British journal of psychiatry : the journal of mental science. 2011;199(6):441-2.
3. Hjorthoj C, Sturup AE, McGrath JJ, Nordentoft M. Years of potential life lost and life expectancy in schizophrenia: a systematic review and meta-analysis. Lancet Psychiatry. 2017;4(4):295-301.
4. Nordentoft M, Wahlbeck K, Hallgren J, Westman J, Osby U, Alinaghizadeh H, et al. Excess mortality, causes of death and life expectancy in 270,770 patients with recent onset of mental disorders in Denmark, Finland and Sweden. PLoS One. 2013;8(1):e55176.
5. Correll CU, Solmi M, Veronese N, Bortolato B, Rosson S, Santonastaso P, et al. Prevalence, incidence and mortality from cardiovascular disease in patients with pooled and specific severe mental illness: a large-scale meta-analysis of 3,211,768 patients and 113,383,368 controls. World Psychiatry. 2017;16(2):163-80.
6. Leucht S, Burkard T, Henderson J, Maj M, Sartorius N. Physical illness and schizophrenia: a review of the literature. Acta psychiatrica Scandinavica. 2007;116(5):317-33.
7. Vancampfort D, Correll CU, Galling B, Probst M, De Hert M, Ward PB, et al. Diabetes mellitus in people with schizophrenia, bipolar disorder and major depressive disorder: a systematic review and large scale meta-analysis. World Psychiatry. 2016;15(2):166-74.
8. Vancampfort D, Stubbs B, Mitchell AJ, De Hert M, Wampers M, Ward PB, et al. Risk of metabolic syndrome and its components in people with schizophrenia and related psychotic disorders, bipolar disorder and major depressive disorder: a systematic review and meta-analysis. World Psychiatry. 2015;14(3):339-47.
9. Kisely S, Sadek J, MacKenzie A, Lawrence D, Campbell LA. Excess cancer mortality in psychiatric patients. Canadian journal of psychiatry Revue canadienne de psychiatrie. 2008;53(11):753-61.
10. Kisely S, Crowe E, Lawrence D. Cancer-related mortality in people with mental illness. JAMA psychiatry. 2013;70(2):209-17.
11. Lawrence D, Holman CD, Jablensky AV, Threlfall TJ, Fuller SA. Excess cancer mortality in Western Australian psychiatric patients due to higher case fatality rates. Acta psychiatrica Scandinavica. 2000;101(5):382-8.
12. Cunningham R, Sarfati D, Stanley J, Peterson D, Collings S. Cancer Survival in the Context of Mental Illness: A national cohort study. General Hospital Psychiatry.37(6):501-6.
13. Baillargeon J, Kuo YF, Lin YL, Raji MA, Singh A, Goodwin JS. Effect of mental disorders on diagnosis, treatment, and survival of older adults with colon cancer. J Am Geriatr Soc. 2011;59(7):1268-73.
14. Irwin KE, Henderson DC, Knight HP, Pirl WF. Cancer care for individuals with schizophrenia. Cancer. 2014;120(3):323-34.
15. Firth J, Siddiqi N, Koyanagi A, Siskind D, Rosenbaum S, Galletly C, et al. The Lancet Psychiatry Commission: A Blueprint for Protecting Physical Health in People with Mental Illness. The Lancet Psychiatry. 2019;in press: doi: 10.1016/S2215-0366(19)30132-4.
16. Chang CK, Hayes RD, Broadbent MT, Hotopf M, Davies E, Moller H, et al. A cohort study on mental disorders, stage of cancer at diagnosis and subsequent survival. BMJ open. 2014;4(1):e004295.
17. Lord O, Malone D, Mitchell AJ. Receipt of preventive medical care and medical screening for patients with mental illness: a comparative analysis. Gen Hosp Psychiatry. 2010;32(5):519-43.
18. Aggarwal A, Pandurangi A, Smith W. Disparities in breast and cervical cancer screening in women with mental illness: a systematic literature review. Am J Prev Med. 2013;44(4):392-8.

19. Mitchell AJ, Pereira IE, Yadegarfar M, Pepereke S, Mugadza V, Stubbs B. Breast cancer screening in women with mental illness: comparative meta-analysis of mammography uptake. The British journal of psychiatry : the journal of mental science. 2014;205(6):428-35.
20. Moher D, Shamseer L, Clarke M, Ghersi D, Liberati A, Petticrew M, et al. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. Systematic reviews. 2015;4(1):1.
21. Stroup DF, Berlin JA, Morton SC, Olkin I, Williamson GD, Rennie D, et al. Meta-analysis of observational studies in epidemiology: a proposal for reporting. Jama. 2000;283(15):2008-12.
22. Wells GA SB, O'Connell D, Peterson J, Welch V, Losos M, Tugwell P. The Newcastle-Ottawa Scale (NOS) for Assessing the Quality of Nonrandomised Studies in Meta-analyses. Available at http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp2017.
23. DerSimonian R, Laird N. Meta-analysis in clinical trials. Control Clin Trials. 1986;7(3):177-88.
24. DerSimonian R, Kacker R. Random-effects model for meta-analysis of clinical trials: an update. Contemp Clin Trials. 2007;28(2):105-14.
25. Higgins JP, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta-analyses. BMJ. 2003;327(7414):557-60.
26. Egger M, Davey Smith G, Schneider M, Minder C. Bias in meta-analysis detected by a simple, graphical test. BMJ. 1997;315(7109):629-34.
27. Duval S, Tweedie R. Trim and fill: A simple funnel-plot-based method of testing and adjusting for publication bias in meta-analysis. Biometrics. 2000;56(2):455-63.
28. Arbyn M, Castellsague X, de Sanjose S, Bruni L, Saraiya M, Bray F, et al. Worldwide burden of cervical cancer in 2008. Annals of oncology : official journal of the European Society for Medical Oncology / ESMO. 2011;22(12):2675-86.
29. Thomas M, James M, Vittinghoff E, Creasman JM, Schillinger D, Mangurian C. Mammography Among Women With Severe Mental Illness: Exploring Disparities Through a Large Retrospective Cohort Study. Psychiatr Serv. 2018;69(1):48-54.
30. Baillon S, Murray J. A national survey of psychiatrists' attitudes towards the physical examination. J Ment Health. 2019:1-7.
31. Murray J, Baillon S, Bruce J, Velayudhan L. A survey of psychiatrists' attitudes towards the physical examination. J Ment Health. 2015;24(4):249-54.
32. Jensen LF, Mukai TO, Andersen B, Vedsted P. The association between general practitioners' attitudes towards breast cancer screening and women's screening participation. BMC Cancer. 2012;12:254.
33. Robson D, Haddad M, Gray R, Gournay K. Mental health nursing and physical health care: a cross-sectional study of nurses' attitudes, practice, and perceived training needs for the physical health care of people with severe mental illness. Int J Ment Health Nurs. 2013;22(5):409-17.
34. Blythe J, White J. Role of the mental health nurse towards physical health care in serious mental illness: an integrative review of 10 years of UK literature. Int J Ment Health Nurs. 2012;21(3):193-201.
35. Vilain J, Galliot AM, Durand-Roger J, Leboyer M, Llorca PM, Schurhoff F, et al. [Environmental risk factors for schizophrenia: a review]. L'Encephale. 2013;39(1):19-28.
36. Giorgi Rossi P, Baldacchini F, Ronco G. The Possible Effects on Socio-Economic Inequalities of Introducing HPV Testing as Primary Test in Cervical Cancer Screening Programs. Frontiers in oncology. 2014;4:20.
37. WHO. Mental health in primary care: illusion or inclusion? : World Health Organization. License: CC BY-NC-SA 3.0 IGO; 2018.
38. Morden NE, Mistler LA, Weeks WB, Bartels SJ. Health care for patients with serious mental illness: family medicine's role. J Am Board Fam Med. 2009;22(2):187-95.
39. Planner C, Gask L, Reilly S. Serious mental illness and the role of primary care. Curr Psychiatry Rep. 2014;16(8):458.
40. Rubin G, Berendsen A, Crawford SM, Dommett R, Earle C, Emery J, et al. The expanding role of primary care in cancer control. Lancet Oncol. 2015;16(12):1231-72.
41. Psychiatrists. RAaNZCo. Keeping body and mind together: improving the physical health and life expectancy of people with serious mental illness. . 2015.

42. Galderisi S, Rucci P, Kirkpatrick B, Mucci A, Gibertoni D, Rocca P, et al. Interplay Among Psychopathologic Variables, Personal Resources, Context-Related Factors, and Real-life Functioning in Individuals With Schizophrenia: A Network Analysis. JAMA psychiatry. 2018;75(4):396-404.
43. MacQueen GM, Young LT, Joffe RT. A review of psychosocial outcome in patients with bipolar disorder. Acta psychiatrica Scandinavica. 2001;103(3):163-70.
44. Rocca P, Galderisi S, Rossi A, Bertolino A, Rucci P, Gibertoni D, et al. Social cognition in people with schizophrenia: a cluster-analytic approach. Psychol Med. 2016;46(13):2717-29.
45. Khaykin E, Eaton WW, Ford DE, Anthony CB, Daumit GL. Health insurance coverage among persons with schizophrenia in the United States. Psychiatric services (Washington, DC). 2010;61(8):830-4.
46. Yanos PT, Lu W, Minsky S, Kiely GL. Correlates of health insurance among persons with schizophrenia in a statewide behavioral health care system. Psychiatric services (Washington, DC). 2004;55(1):79-82.
47. Peterson NB, Murff HJ, Cui Y, Hargreaves M, Fowke JH. Papanicolaou testing among women in the southern United States. J Womens Health (Larchmt). 2008;17(6):939-46.
48. Tseng DS, Cox E, Plane MB, Hla KM. Efficacy of patient letter reminders on cervical cancer screening: a meta-analysis. Journal of general internal medicine. 2001;16(8):563-8.
49. Yabroff KR, Zapka J, Klabunde CN, Yuan G, Buckman DW, Haggstrom D, et al. Systems strategies to support cancer screening in U.S. primary care practice. Cancer epidemiology, biomarkers & prevention : a publication of the American Association for Cancer Research, cosponsored by the American Society of Preventive Oncology. 2011;20(12):2471-9.
50. Everett T, Bryant A, Griffin MF, Martin-Hirsch PP, Forbes CA, Jepson RG. Interventions targeted at women to encourage the uptake of cervical screening. Cochrane Database Syst Rev. 2011(5):CD002834.
51. Doran T KE, Valderas JM, Campbell S, Roland M, Salisbury C, Reeves D. Effect of financial incentives on incentivised and non-incentivised clinical activities: longitudinal analysis of data from the UK Quality and Outcomes Framework. BMJ (Clinical Research Ed).342.
52. Bang JY, Yadegarfar G, Soljak M, Majeed A. Primary care factors associated with cervical screening coverage in England. Journal of Public Health. 2012;34(4):532-8.
53. Miller E, Lasser KE, Becker AE. Breast and cervical cancer screening for women with mental illness: patient and provider perspectives on improving linkages between primary care and mental health. Archives of women's mental health. 2007;10(5):189-97.
54. Ilic D, Djulbegovic M, Jung JH, Hwang EC, Zhou Q, Cleves A, et al. Prostate cancer screening with prostate-specific antigen (PSA) test: a systematic review and meta-analysis. Bmj. 2018;362:k3519.
55. Cook BL, Wayne GF, Kafali EN, Liu Z, Shu C, Flores M. Trends in smoking among adults with mental illness and association between mental health treatment and smoking cessation. JAMA. 2014;311(2):172-82.
56. Flores EJ, Park ER, Irwin KE. Improving Lung Cancer Screening Access for Individuals With Serious Mental Illness. J Am Coll Radiol. 2019;16(4 Pt B):596-600.

Figure 1.

Title. PRISMA flow-chart of study selection process

Figure 1. PRISMA flow-chart of study selection process

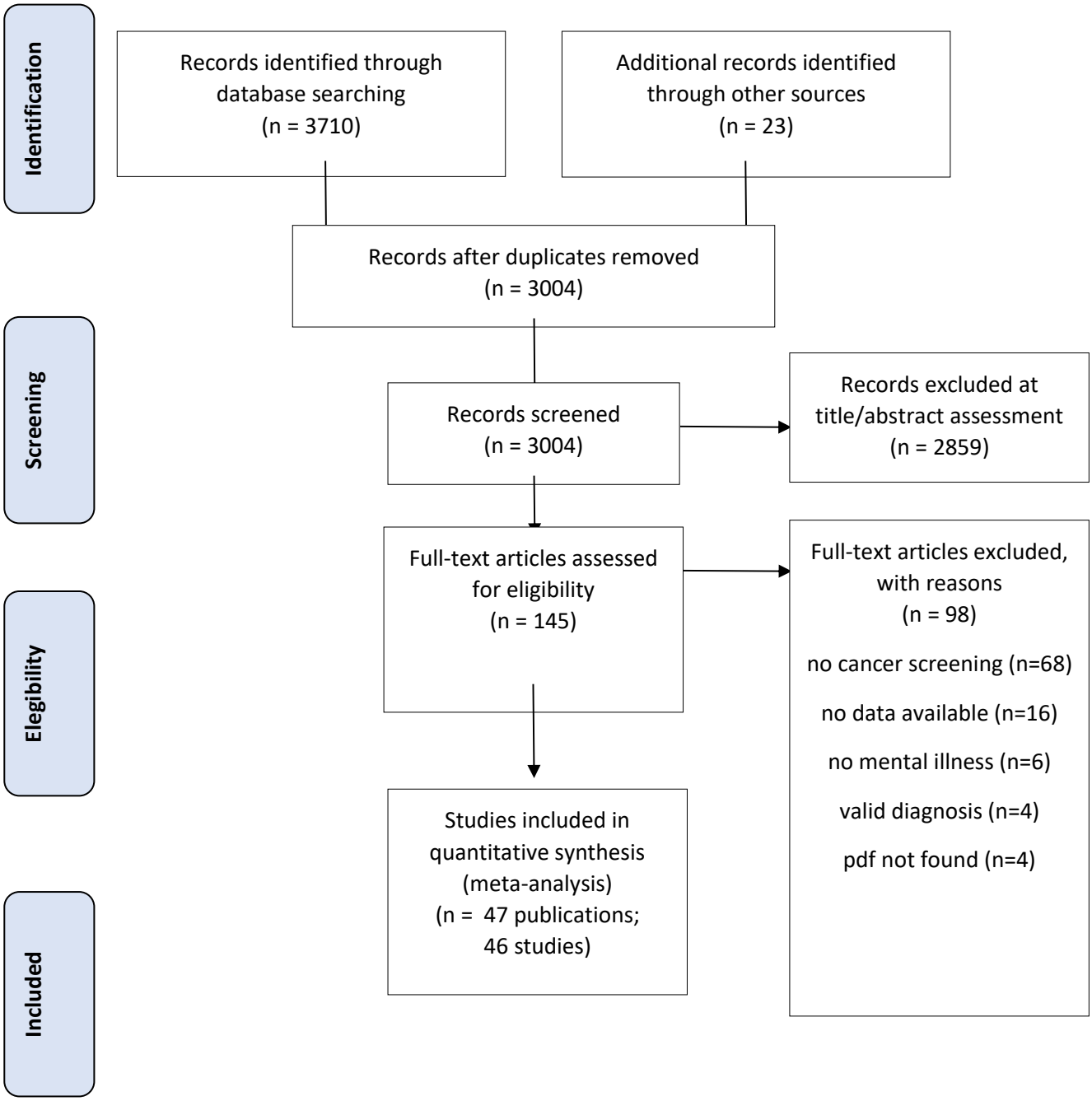
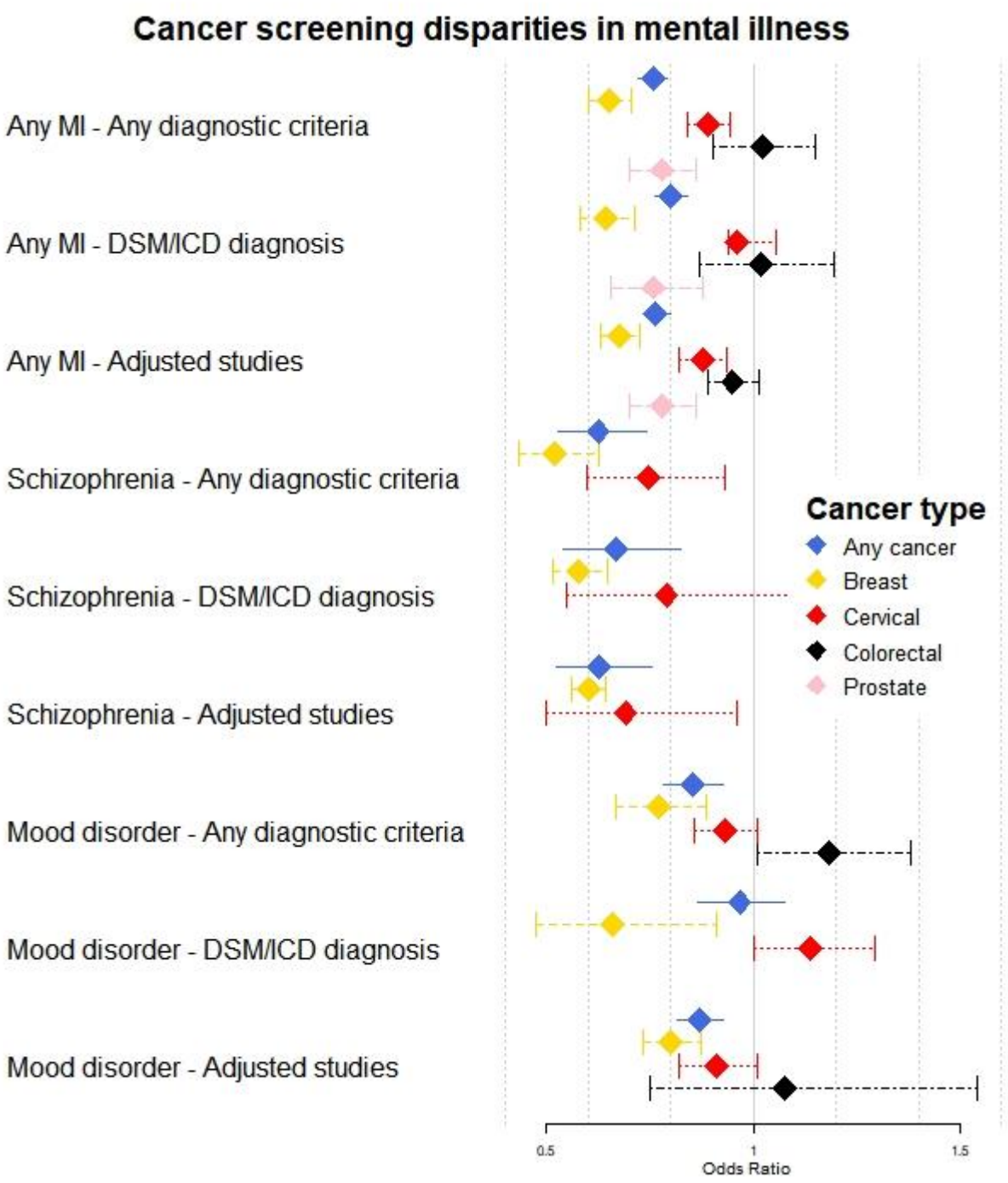


Figure 2.

Title. Forest plot with estimates of disparities in cancer screening between subjects with mental illness and the general population: main and sensitivity analyses

Legend. MI, mental illness



Legend. MI, mental illness.

Table 1. Comparative random effect meta-analysis of cancer screening (breast, cervical, colorectal, prostate) in patients with mental illness compared with general population, and sensitivity analysis on studies using ICD/DSM diagnosis, and adjusted studies.

Cancer screening	Publications/samples	OR (95%CI)*	p value	I^2	Egger's test p value / Fail safe N / Effect size after trim and fill (in case of publication bias)
Any mental illness#					
Any diagnostic criteria					
Any cancer	37/149	0.757 (0.722-0.792)	<0.001	98.53%	0.025 /5174 / 0.905 (0.862-0.951) 39 studies trimmed looking for missing studies to right of mean
Breast	27/85	0.652 (0.603-0.705)	<0.001	97.58%	0.878 /7920
Cervical	23/44	0.891 (0.840-0.945)	<0.001	98.47%	0.811 / 2820
Colorectal	8/11	1.02 (0.903-1.151)	0.753	97.84%	0.463 / NA /
prostate	4/9	0.777 (0.701-0.862)	<0.001	79.68%	0.493 / 457
DSM or ICD diagnosis					
Any cancer	14/78	0.800 (0.762-0.839)	<0.001	97.16%	0.002 / 8808 / 0.948 (0.903-0.996) 20 studies trimmed looking for missing studies to right of mean
Breast	8/44	0.642 (0.579-0.711)	<0.001	96.44%	0.006 / 7798 / 0.674 (0.609-0.745) 4 studies trimmed looking for missing studies to right of mean
Cervical	9/25	0.959 (0.939-1.055)	0.876	97.61%	0.742 / NA
Colorectal	3/5	1.018 (0.869-1.193)	0.821	82.08%	0.481 / NA
Prostate	2/4	0.757 (0.653-0.878)	<0.001	54.72%	0.042 / 49 / 0.813 (0.687-0.962) 2 studies trimmed looking for missing studies to right of mean
Adjusted studies*					
Any cancer	31/121	0.763 (0.731-0.797)	<0.001	97.82%	0.004 / 7846 / 0.898 (0.861-0.938) 30 studies trimmed looking for missing studies to right of mean
Breast	21/69	0.674 (0.628-0.724)	<0.001	96.18%	0.039 / 4057 / 0.799 (0.743-0.859) 17 studies trimmed looking for missing studies to right of mean
Cervical	19/35	0.876 (0.821-0.936)	<0.001	98.67%	0.111 / 153
Colorectal	5/7	0.949 (0.889-1.012)	0.111	70.26%	0.530 / NA
Prostate	4/9	0.777 (0.701-0.862)	<0.001	79.68%	0.494 / 457
Schizophrenia and other non-affective psychoses					
Any diagnostic criteria					
Any cancer	13/24	0.624 (0.525-0.742)	<0.001	98.78%	0.540 / 4696
Breast	8/12	0.518 (0.431-0.624)	<0.001	91.99%	0.604 / 2232
Cervical	7/10	0.746 (0.597-0.932)	0.010	98.59%	0.622 / 163
DSM or ICD diagnosis					
Any cancer	8/14	0.666 (0.539-0.822)	<0.001	98.12%	0.280 / 494
Breast	4/7	0.578 (0.516-0.647)	<0.001	26.62%	0.020 / 249 / 0.621 (0.548-0.704) 4 studies trimmed looking for missing studies to right of mean
Cervical	4/6	0.789 (0.549-1.135)	0.202	99.09%	0.919 / NA
Adjusted studies*					
Any cancer	10/15	0.627 (0.521-0.754)	<0.001	98.09%	0.160 / 1421
Breast	5/8	0.601 (0.561-0.644)	<0.001	15.58%	0.029 / 517 / 0.617 (0.566-0.672) 4 studies trimmed looking for missing studies to right of mean
Cervical	5/6	0.690 (0.497-0.958)	0.027	99.10%	0.614 / 136
Mood disorders					
Any diagnostic criteria					

Table 2. Region subgroup random effect meta-analysis of cancer screening (breast, cervical, colorectal, prostate) in patients with mental illness #

Country/region	Publications/samples	OR (95%CI)*	p value	I^2	Subgroup difference across different regions p value
Any mental illness					
Any cancer					
Israel	2/2	0.807(0.750-0.869)	<0.001	39.50%	0.085
Europe	6/25	0.777(0.728-0.829)	<0.001	97.87%	
USA*	21/105	0.769(0.717-0.825)	<0.001	98.41%	
Australia	2 / 5	0.762(0.697-0.834)	<0.001	94.90%	
Canada*	6/9	0.729(0.587-0.905)	0.004	88.55%	
Asia	1/3	0.302(0.157-0.581)	<0.001	NA	
Breast cancer					
Canada*	4/4	0.929(0.523-1.650)	0.8	63.73%	0.016
Israel	1/1	0.767(0.691-0.851)	<0.001	NA	
USA*	18/65	0.667(0.608-0.732)	<0.001	97.97%	
Europe	4/12	0.655(0.573-0.749)	<0.001	91.82%	
Asia	1/3	0.302(0.157-0.581)	<0.001	NA	
Cervical cancer					
USA*	14/24	0.980(0.880-1.092)	0.714	96.98%	<0.001
Europe	3/12	0.880(0.822-0.941)	<0.001	97.97%	
Australia	2 / 3	0.728(0.674-0.787)	<0.001	8.14%	
Canada*	5/5	0.670(0.491-0.914)	0.012	92.73%	
Colorectal cancer					
Europe	1/1	1.300(1.095-1.543)	0.003	NA	<0.001
USA	6/9	1.011(0.879-1.163)	0.878	98.05%	
Australia	1/1	0.900(0.861-0.941)	<0.001	NA	
Prostate cancer					
Israel	1/1	0.830(0.781-0.882)	<0.001	NA	<0.001
USA	2/7	0.772(0.638-0.935)	0.008	69.38%	
Australia	1/1	0.720(0.700-0.740)	<0.001	NA	
Schizophrenia spectrum disorders					
Any cancer					
Israel	1 / 1	0.830(0.781-0.882)	<0.001	NA	<0.001
Canada	2/6	0.674(0.618-0.735)	<0.001	50.26%	
USA	5/13	0.619(0.449-0.852)	0.003	99.16%	
Europe	5/8	0.545(0.409-0.727)	<0.001	98.36%	
Breast cancer					
Canada	1 / 1	0.640(0.578-0.708)	<0.001	NA	0.090
Europe	3/4	0.576(0.504-0.659)	<0.001	41.03%	
USA	4/7	0.463(0.345-0.623)	<0.001	67.29%	

Table 3. Subgroup meta-analysis of disparities in any cancer screening between schizophrenia spectrum disorder and mood disorders, and in program vs opportunistic screening

Mental illness	Cancer	Publications/samples	Odds ratio and p value	Heterogeneity	Subgroup difference between schizophrenia and mood disorders p value
Diagnostic spectrum					
Schizophrenia spectrum disorders	Any cancer	13/24	0.624 (0.525-0.742); p < 0.001	98.78%	0.002
Mood disorders	Any cancer	25/49	0.851 (0.783-0.926); p < 0.001	98.84%	
Schizophrenia spectrum disorders	Breast cancer	8/12	0.518 (0.431-0.624); p < 0.001	91.99%	0.001
Mood disorders	Breast cancer	18/24	0.770 (0.658-0.886); p < 0.001	98.09%	
Schizophrenia spectrum disorders	Cervical cancer	7/10	0.746 (0.597-0.932); p = 0.010	98.59%	0.069
Mood disorders	Cervical cancer	16/19	0.930 (0.856-1.011); p = 0.090	96.84%	
Program vs opportunistic					
Program	Breast and cervical cancer	28/131	0.734 (0.698-0.772); p<0.001	98.53%	0.002
Opportunistic	Colon and prostate cancer	2/18	0.905 (0.803-1.019), p=0.1	98.35%	

Table 4. Meta-analysis of prevalence of cancer screening (breast, cervical, colorectal, prostate, gastric, lung, ovarian) in patients with mental illness (defined according to any criteria), and subgroup analysis across countries and between schizophrenia and mood disorders.

Country/region and Mental illness	Cancer	Publications/samples	Prevalence	Heterogeneity	Subgroup comparison between schizophrenia and mood disorders
Any cancer					
Any mental illness	Any cancer	34/155	56.5% (51.5-61.3)	99.91%	
Australia	Any cancer	1/2	87.6% (78-93.4)	NA	<0.001
Europe	Any cancer	6/23	69.5% (64.1-74.4)	99.54%	
Canada	Any cancer	3/3	61.7% (43.4-77.2)	99.46%	
USA	Any cancer	19/111	58.8% (53.4-64)	99.9%	
Israel	Any cancer	2/2	34.4% (19.6-53)	99.74%	
Asia	Any cancer	3/14	18% (11.9-26.4)	96.83%	
Mood disorders	Any cancer	19/35	50.6% (41.4-59.8)	99.94%	0.408
Schizophrenia spectrum disorders	Any cancer	16/36	44.5% (33.9-55.6)	99.87%	
Breast cancer					
Any mental illness	Breast cancer	25/81	61.9% (54.7-68.6)	99.89%	
Australia	Breast cancer	1/1	91.5% (83.2-95.9)	NA	<0.001
USA	Breast cancer	16/65	65.6% (57.9-72.6)	99.89%	
Europe	Breast cancer	3/9	56.9% (50.5-63.1)	96.16%	
Canada	Breast cancer	1/1	44.8% (42.3-47.4)	NA	
Israel	Breast cancer	1/1	43.7% (42.2-45.2)	NA	
Asia	Breast cancer	1 /4	15.4% (8.7-26)	NA	
Mood disorders	Breast cancer	13/16	57.9% (41.4-7.28)	99.92%	0.570
Schizophrenia spectrum disorders	Breast cancer	12/17	52.3% (41.8-62.5)	99.53%	
Cervical cancer					
Any mental illness	Cervical cancer	20/42	59.7% (49.4-69.2)	99.94%	
Australia	Cervical cancer	1/1	84% (75.5-90)	NA	<0.001
Canada	Cervical cancer	2/2	69.4% (47.7-84.9)	99.48%	
Europe	Cervical cancer	3/12	81.4% (78.1-84.3)	99.62%	
USA	Cervical cancer	12/25	47% (38.3-55.9)	99.9%	
Asia	Cervical cancer	2/2	19.3% (2.8-66.4)	96.39%	
Mood disorders	Cervical cancer	11/12	52.9% (31.1-73.6)	99.97%	0.654
Schizophrenia spectrum disorders	Cervical cancer	10/14	46.7% (32.8-61.1)	99.74%	
Colorectal cancer					
Any mental illness	Colorectal cancer	10/18	37.1% (28.9-46.1)	99.79%	
USA	Colorectal cancer	7/12	46.7% (35.8-57.9)	99.86%	<0.001
Europe	Colorectal cancer	1/1	27% (15.2-43.3)	NA	
Asia	Colorectal cancer	2 /5	19.3% (13.1-27.6)	7%	
Mood disorders	Colorectal cancer	5/5	34.0% (19.4-52.4)	99.89%	0.525

Table 5. Meta-regression between the gap in screeing rates between the general population and subjects with mental illness, and the screening rates in the general population.

Cancer	**Publications/samples**	**Beta**	**95%CI**	**P value**
Any cancer	35/143	-0.79	-1.18 - -0.39	<0.001
Breast cancer	26/84	0.35	-0.21 – 0.91	0.223
Cervical cancer	21/42	-1.46	-2.12 - -0.80	<0.001
Colorectal cancer	6/9	-0.76	-1.13 - -0.39	<0.001
Prostate cancer	3/8	-0.51	-1.68 - -0.68	0.404

Disparities in cancer screening in people with mental illness across the world: prevalence and comparative meta-analysis versus the general population including 4,717,839 people

Supplementary material content

Supplementary table 1. Characteristics of studies reporting on disparities or prevalence of cancer screening in subjects suffering from mental illness

Author	Diagnostic criteria	Screening period (years)	Age	Psychiatric disorder	N patients	N controls	N total	Country	Female %	Cancer	Screening procedure	Adjusted (Y/N)	which variables are analyses adjusted for	Association measure	Prevalence
Abrams, 2012 (1)	ICD-9	1	41,00	substance use disorder	6122	85375	105 681	USA	100,00%	cervical	pap smear	Y	age, region, comorbidity, diagnosis, race.	Y	Y
			46,00	psychosis	4747										
			42,00	psychosis and substance use disorder	1104										
			41,00	bipolar disorder or mania	3319										
			43,00	depression	5014										
Aggarwal, 2008 (2)	CES-D	1	57(50-79)	depressive symptoms	12621	67368	79 989	USA	100,00%	breast	mammography	N		Y	Y
										colon	colonscopy				
Blackwell, 2008 (3)	Composite International Diagnostic Interview	2	18 - 69	major depressive episodes	496	4358	4 854	USA/Canada	100,00%	breast	mammography	Y	demographic, socio-economic, health staus and other variables	Y	N
										cervical	pap smear				
Carney, 2006 (4)	DSM-IV	5	48,30	mood disorder	22512	131683	191 356	USA	100,00%	breast	mammography	Y	age, rural location, utilization of nonmental health services, and severity and type of the mental disorder.	Y	Y
				psychotic disorders	525										
				adjustment disorders	8656										
				anxiety disorders	9340										
				low severity other mental disorder	2113										

				sexual disorder	3175											
				sleep disorder	3454											
				somatoform disorder	3121											
				substance disorder	6777											
Chochinov, 2009 (5)	ICD-9	2	50-69	schizophrenia	1448	108792	110 240	Canada	100,00%	breast	mammography	Y	age, region, average household income, continuity of care, and physical comorbid-Ities.	Y	Y	
Domino, 2014 (6)	clinical records	3	≥50	schizophrenia	15636	106555	188 531	USA	66,00%	colon	colon screening	Y	inpatient hospital days	Y	Y	
			≥45						100,00%	breast	mammography					
			21-65						100,00%	cervical	cervical screening					
			≥50	depression	66340				66,00%	colon	colon screening					
			≥40						100,00%	breast	mammography					
			21-65						100,00%	cervical	cervical screening					
Druss, 2002 (7)	ICD-9	3	<=65	psychiatric disorder only (ICD-9 codes 290 –302 and 306 – 319)	3 000 all	4 030	7 030	USA	100,00%	cervical	pap smear	Y	demographic, health status, and facility-level characteristics.	Y	Y	
		2	50-69						100,00%	breast	mammography					
		1	>=50						0,00%	prostate	PSA					
		1	>=50						21,00%	colon	fecal occult blood					
		3	<=65	substance use disorder					100,00%	cervical	pap smear					
		2	50-69						100,00%	breast	mammography					
		1	>=50						0,00%	prostate	PSA					
		1	>=50						21,00%	colon	fecal occult blood					
		3	<=65	dual diagnosis (co-morbid psychiatric and substance use disorders).					100,00%	cervical	pap smear					

		2	50-69					100,00%	breast	mammography				
		1	>=50					0,00%	prostate	PSA				
		1	>=50					21,00%	colon	fecal occult blood				
Druss, 2008 (8)	CIDI-SF>=3 (DSM-III)	1	>50	major depressive disorder	2220	27861	30 081	USA	69,80%	colon	fecal occult blood	Y	gender, race, age, poverty status, insurance coverage and number of chronic medical conditions.	Y	N
			>40						100,00%	breast	mammography				
			<65						100,00%	cervical	pap smear				
Eriksson, 2019(9)	ICD-10	5	23-60	Schizophrenia spectrum disorders	2364	275879	341 171	Sweden	100%	cervical	Pap smear	Y	age	Y	Y
				Mood disorders	43832										
				Phobia, anxiety, stress-related disorders	19096										
Folsom, 2002(10)	DSM-IV	1	51,5(≥45)	schizophrenia or schizoaffective disorders	47	NA	94	USA	47,00%	colon	fecal occult blood	N		N	Y
									100,00%	breast	mammography				
									100,00%	cervical	pelvic examination				
			51,3(≥45)	major depressive disorder	47				47,00%	colon	fecal occult blood				
									100,00%	breast	mammography				
									100,00%	cervical	pelvic examination				
Fujiwara AND Inagaki, 2017, 2018 (11, 12)	DSM-5	1	44,8 (40-69)	schizophrenia or schizoaffective disorders	420	NA	420	japan	51,30%	colon	colon screening	N		N	Y
		1	44,8 (40-69)						51,10%	gastric	gastric screening				
		1	44,8 (40-69)						51,30%	lung	lung screening				
		2	44,8 (40-69)						100,00%	breast	mammography				
		2	20-69						100,00%	cervical	pap smear				

Gal,2014 (13)	ICD-10	8	61,00	schizophrenia	8285	16570	24 855	Israel	0,00%	prostate	PSA	Y	sum of PSA tests	Y	Y
Green, 2000 (14)	SF-36	lifetime	52,9(18-102)	Depression	1173	2299	3 472	USA	100,00%	breast	mammography	Y	income, self-reported social-class, health status.	Y	N
										cervical	pap smear				
Harder, 2018 (15)	ICD-10	2	23-49	Intoxicant abuse	3188	419552	466 419	Denmark	100%	cervical	pap smear	Y	age, country of origin, marital status, educational level, income	Y	Y
				schizophrenia and other psychoses	4454										
				affective disorders	13927										
				anxiety and Obsessive-compulsive disorders	21641										
				eating disorders	3657										
Holden, 2015 (16)	CES-D	na	na	depression	37	NA	37	UK	100%	Ovarian	na	N	-	N	Y
										colorectal	na				
Iezzoni, 2001 (17)	NHIS-D	2	>50	serious mental health problem	1944	75818	77 762	USA	100,00%	breast	mammography	Y	age	Y	N
			42,4(18-65)							cervical	pap smear				
			>30							breast	breast examination				
Jensen, 2016 (18)	clinical records	10	50 - 69	Schizophrenia	1 022	137 692	144 264	Denmark		breast	mammography	Y	age, marital status, ethnicity, education, psychiatric comorbidity	Y	Y
				Affective disorders	3 453										
				Anxiety disorders	670										
				Substance abuse	1 427										

Kaida, 2008 (19)	DSM-IV, ICD-10	3	18-69	depression	1831	23521	25 352	Canada	100,00%	cervical	pap smear	Y	age, education, income, marital status, ethnicity, healthcare utilization	Y	Y
Katz,2018 (20)	clinical records	6	50-74	depression	4354	39964	44,318	Israeli	100%	breast	mammography	Y	Socio-demographic factors and comorbidities	Y	Y
Kempe, 2013 (21)	clinical records	2	52-69	depression	9269	38677	47 946	USA	100,00%	breast	mammography	Y	socioeconomic and health status variable	Y	Y
Koroukian, 2012 (22)	ICD-9-CM	6	50-64	mental illness and/or alcohol/substance abuse	61661	68427	130 088	USA	100,00%	breast	mammography	Y	comorbid conditions and length of enrollment in Medicaid	Y	N
Kotwal, 2012(23)	CES-D, HADS, PSS-4	1	57-85	depression anxiety	120	1 049	1 169	USA	0%	prostate	PSA	Y	Age, ethnicity, marital status, education, income	Y	Y
Lasser, 2003 (24)	modified version of PRIME-MD	2	40-70	anxiety disorders eating disorders mood disorders PTSD substance abuse somatisation psychotic disorders	103 28 84 27 46 79 12	293	672	USA	100,00%	breast	mammography	N		Y	Y
Lindamer, 2003 (25)	clinical records, PANSS, HAM-D	2 3 2	57,6(50-79) 57,6 (50-79)	schizophrenia schizophrenia or schizoaffective disorders	65	51	116	USA	100,00% 100%	breast cervical cervical breast	mammography pap smear pelvic examination and pap test mammography	N		Y	Y

Lindamer, 2006(26)	DSM-IV	lifetime	52,9 (44-72)	schizophrenia or schizoaffective disorders	46	NA	46	USA	100,00%	breast	mammography	N		N	Y
Long, 1998 (27)	clinical records	lifetime	49,1(41-50)	mental health treatment, hospitalization	43	62	105	USA	100,00%	breast	mammography	N		Y	Y
		1	41,70							breast	breast examination				
		1	39,90							cervical	pap smear				
Ludman, 2010 (28)	PHQ-9	2	51-65	depression	755	3904	4 659	USA	100,00%	breast	mammography	Y	age, ethnicity, marital status, education, current smoker, comorbidity, body dissatisfaction	Y	Y
		3	40-65							cervical	pap smear				
Martens, 2009 (29)	clinical records	3	18-69	schizophrenia	3220	335294	338 514	Canada	100%	cervical	pap smear	Y	age, region, income, continuity of care, physical comorbidities	Y	Y
Masterson, 2010 (30)	Kentucky 2002 BRFSS	lifetime	≥40	low depression	543	2818	5 101	USA	100,00%	breast	mammography	Y	age, race, marital status, education, income, and health insurance status	Y	N
				high depression	192										
				very high depression	307										
				low anxiety	622										
				high anxiety	238										
				very high anxiety	381										
Mo, 2014 (31)	clinical records	lifetime	21-65	Severe mental illness	591	NA	591	Hong kong	100,00%	cervical	pap smear	N		N	Y
			>=40						100,00%	breast	mammography				
			>=40						100,00%	breast	breast examination				
			>=50						54,00%	colon	fecal occult blood				
			>=50						54,00%	colon	flexible sigmoidoscopy				
			>=50						54,00%	colon	colonscopy				

			>=50						54,00%	colon	double contrast barium enema				
			>=50						0,00%	prostate	digital rectal exam				
Olesen, 2012 (32)	Goldberg anxiety scale >7	2	44-68	anxiety	295	1657	2 095	Australia	100,00%	cervical	pap smear	Y	age	Y	N
	Goldberg depression scale >7			depression	143										
Owen, 2002 (33)	clinical records	lifetime	46,30	mood disorders, schizophrenia, primary anxiety disorder, other mental disorders	100	NA	100	Australia	100,00%	cervical	pap smear	N		N	Y
										breast	breast examination				
Patten, 2009 (34)	CIDI-SF	2	50-69	major depression	2651	3631	6 282	Canada	100,00%	breast	mammography	Y	age, sex, rural place of residence, education level, a diagnosis of hypertension, other chronic conditions, income and employment status	Y	N
			≥18							cervical	pap smear				
Peytremann-Bridevaux, 2008 (35)	EURO-D>3	10	67,6(≥50)	depressive symptoms	10335	5045	15 380	UE	70,50%	colorectal	colonscopy or flexible sigmoidoscpy	Y	age, gender, socioeconomic status, behavioral risk, chronic disease, disability, country	Y	N
		2	67,6(≥50)						100,00%	breast	breast screening				

Pirraglia, 2004 (36)	CES-D_=21	1	42-52	high depressive symptoms	492	2 493	3 297	USA	100,00%	breast	mammography	Y	age, race/ethnicity, health insurance, medical history and use, smoking, obesity, and socioeconomic status	Y	N
										cervical	pap smear				
				moderate depressive symptoms	312					breast	mammography				
										cervical	pap smear				
Salsberry, 2005 (37)	ICD-9-CM	3	≥18	schizophrenic disorders	158	NA	669	USA	100,00%	cervical	pap smear	N		N	Y
			≥40							breast	mammography				
			≥18	paranoid disorders	72					cervical	pap smear				
			≥40							breast	mammography				
			≥18	affective disorders	379					cervical	pap smear				
			≥40							breast	mammography				
			≥18	anxiety disorders	60					cervical	pap smear				
			≥40							breast	mammography				
Stecker, 2007 (38)	DSM	5	41,40	depression	270	590	860	USA	100,00%	breast	mammography	N		Y	Y
										cervical colon	pap smear colonscopy				
Thomas, 2018 (39)	DSM-IV-TR	1	48-67	anxiety disorders	641	NA	14 651	USA	100%	breast	mammography	N		N	Y
				bipolar disorders	2115										
				major depressive disorder	4806										
				other psychiatric disorders	754										
				schizophrenia	6335										
Tuesley, 2018 (40)	clinical records	7.5 to 11	18-69	Schizophrenia or bipolar disorder	41169	2017267	2 058 436	Australia	50%	colorectal	Fecal occult blood	Y	Age, gender, state, number visits with general practitioner per year	Y	N

										Cervical	Pap smear					
										prostate	PSA					
Vigod, 2011(41)	DSM-IV	2	56,30	major depressive disorder	67	840	1 398	Canada	100,00%	breast	mammography	Y	Age, income level, level of education, geograph-ical variability (urban/rural), body mass index, and medical and psychiatric comorbidity	Y	N
	Kessler 6-item >8		58(40-70)	clinically significant depressive symptoms	491					cervical	pap smear				
Werneke, 2006 (42)	ICD-10	3	50-64	any psychiatric condition	1048	53340	54 388	UK	100,00%	breast	breast screening	Y	mental health variable including level of psychiatric care, number of inpatient episodes and detention, diagnosis, and the total lenght of time a patient had been seen by the psychiatric service.	Y	Y
Weitlauf, 2013 (43)	ICD-9	5	18-65	PTSD	5668	16828	34 123	USA	100,00%	cervical	pap smear	Y	age, income, physical comorbidities	Y	Y
				depression	11627										
Woodhead, 2016 (44)	ICD-10	3	50-70	schizophrenia	406	132293	133 184	UK	100,00%	breast	mammography	Y	age, ethnicity, deprvation, primary-care consultation frequency	Y	Y
			25-64	bipolar affective disorder	298					cervical	pap smear				
			50-70							breast	mammography				
			25-64							cervical	pap smear				

			50-70	Other non-organic psychoses	187					breast	mammography					
			25-64							cervical	pap smear					
Xiong, 2008 (45)	DSM-IV-TR	lifetime	40,10	Severe mental illness	229	NA	229	USA	100,00%	cervical	pap smear	N		N	Y	
			40,10						100,00%	breast	mammography					
			40,10						100,00%	breast	breast examination					
			>50						0,00%	prostate	PSA					
			>50						0,00%	prostate	digital rectal exam					
			>50						54,00%	colorectal	fecal occult blood					
			>50						54,00%	colorectal	flexible sigmoidoscopy					
Yee, 2011 (46)	ICD-9	3	57,2(50-65)	Anxiety, depressed mood, dissociative symptoms, eating disorders, impulse control disorders, manic symptoms, personality disorders, psychosis, somatoform disorders, and substance use disorders.	321	250	571	USA	100,00%	cervical	pap smear	Y	age, insurance, service connection, and primary care and women's clinic visits.	Y	Y	
										colorectal	Fecal occult blood, flexible sigmoidoscopy, colonscopy					
										breast	mammography					

Yen, 2014 (47)	clinical records	2	50-69	delusional disorders, affective disorders, schizophrenia, childhood-onset mental disorder, senile and presenile mental disorders, other organic and nonorganic mental disorders	13089	4154	17 243	Taiwan	100%	breast	mammography	N		Y	Y
46studies (47 publications)	20 DSM/ICD 13 scale 10 clinical records 3 mixed	7 1 year, 11 2 years, 6 3 years, 9 4 years and more, 6 mixed, 6 lifetime, 1 NA	Range 18-79	14 depression, 6 schizophrenia, 14 mixed with specific diagnoses, 12 mixed without specific diagnosis	501 559	4 216 280	4 717 839	25 USA, 3 UK, 1 Taiwan, 1 Hong Kong, 5 Canada, 1 EU, 2 Denmark,1 Sweden, 2 Israel, 1Japan, 3 Australia, 1 USA/Canada	35 Only women, 2 only men 9 mixed	12 breast only, 6 cervical only, 2 prostate only, 26 mixed	11 Mammography, 1 breast examination, 6 pap smear, 2 PSA, 25 mixed, 1 NA	31 Adjusted, 15 non adjusted		37 with association measure, 9 without association measure	34 with prevalence measure, 12 without prevalence measure

Supplementary table 2. Quality of included studies according to Newcastle-Ottawa Scale.

Study	Selection				Comparability	Outcome			Total
	Representativeness of the exposed cohort	Selection of the non exposed cohort	Ascertainment of exposure	Demonstration that outcome of interest was not present at start of study	Comparability of cohorts on the basis of the design or analysis	Assessment of outcome	Was follow-up long enough for outcomes to occur	Adequacy of follow up of cohorts	
Abrams, 2012 (1)	*	*	*	-	**	*	*	-	7
Aggarwal, 2008 (2)	*	*	*	*	**	*	*	*	9
Blackwell, 2008 (3)	*	*	-	*	**	*	*	-	7
Carney, 2006 (4)	*	*	*	*	**	*	*	*	9
Chochinov, 2009 (5)	*	*	*	*	**	*	*	-	8
Domino, 2014 (6)	*	*	*	*	*	*	*	-	7
Druss, 2002 (7)	*	*	*	-	*	*	*	-	6
Druss, 2008 (8)	*	*	*	-	*	*	*	-	6
Eriksson, 2019(9)	*	*	*	*	*	*	*	*	8
Folsom, 2002(10)	*	-	*	*	-	*	*	-	5

Study	Selection				Comparability	Outcome			Total
	Representativeness of the exposed cohort	Selection of the non exposed cohort	Ascertainment of exposure	Demonstration that outcome of interest was not present at start of study	Comparability of cohorts on the basis of the design or analysis	Assessment of outcome	Was follow-up long enough for outcomes to occur	Adequacy of follow up of cohorts	
Fujiwara AND Inagaki, 2017, 2018 (11, 12)	*	-	*	-	-	*	-	-	3
Gal,2014 (13)	*	*	*	-	*	*	*	*	7
Green, 2000 (14)	*	-	-	*	**	*	-	*	6
Harder, 2018 (15)	*	*	*	*	**	*	*	-	8
Holden, 2015 (16)	*	-	-	*	-	*	*	-	4
Iezzoni, 2001 (17)	*	-	*	*	*	*	*	*	7
Jensen, 2016 (18)	*	*	*	*	**	*	*	*	9
Kaida, 2008 (19)	*	-	*	-	**	*	-	-	5
Katz,2018 (20)	*	*	*	*	**	*	*	*	9
Kempe, 2013 (21)	*	*	*	*	**	*	*	*	9
Koroukian, 2012 (22)	*	*	*	*	**	*	*	*	9
Kotwal, 2012(23)	*	-	-	*	**	-	*	-	5

Study	Selection				Comparability	Outcome			Total
	Representativeness of the exposed cohort	Selection of the non exposed cohort	Ascertainment of exposure	Demonstration that outcome of interest was not present at start of study	Comparability of cohorts on the basis of the design or analysis	Assessment of outcome	Was follow-up long enough for outcomes to occur	Adequacy of follow up of cohorts	
Lasser, 2003 (24)	*	-	*	*	-	*	*	*	6
Lindamer, 2003 (25)	-	-	*	*	-	*	*	*	5
Lindamer, 2006(26)	-	-	*	*	-	*	*	*	5
Long, 1998 (27)	*	-	*	*	-	*	-	*	4
Ludman, 2010 (28)	*	*	-	*	**	*	-	*	7
Martens, 2009 (29)	*	*	*	*	**	*	*	-	8
Masterson, 2010 (30)	*	-	-	*	**	*	-	*	6
Mo, 2014 (31)	*	-	*	*	-	*	-	*	5
Olesen, 2012 (32)	*	-	*	*	*	*	*	*	7
Owen, 2002 (33)	*	-	*	*	-	*	*	*	6
Patten, 2009 (34)	*	*	*	*	**	*	*	-	8
Peytremann-Bridevaux, 2008 (35)	*	*	*	*	**	*	*	-	8
Pirraglia, 2004 (36)	*	*	-	*	**	-	*	*	7

Study	Selection				Comparability	Outcome			Total
	Representativeness of the exposed cohort	Selection of the non exposed cohort	Ascertainment of exposure	Demonstration that outcome of interest was not present at start of study	Comparability of cohorts on the basis of the design or analysis	Assessment of outcome	Was follow-up long enough for outcomes to occur	Adequacy of follow up of cohorts	
Salsberry, 2005 (37)	*	-	*	*	-	*	*	*	6
Stecker, 2007 (38)	*	*	*	-	-	*	*	*	6
Thomas, 2018 (39)	*	-	*	*	-	*	*	*	6
Tuesley, 2018 (40)	*	*	*	*	**	*	*	*	9
Vigod, 2011(41)	*	*	*	*	**	*	*	*	9
Werneke, 2006 (42)	*	*	*	*	**	*	*	-	8
Weitlauf, 2013 (43)	*	*	*	*	**	*	-	-	7
Woodhead, 2016 (44)	*	*	*	*	**	*	*	-	8
Xiong, 2008 (45)	*	-	*	-	-	-	*	*	4
Yee, 2011 (46)	*	*	*	*	**	*	*	*	9
Yen, 2014 (47)	*	*	*	-	-	*	*	*	6

Supplementary table 3. Excluded studies after full text assessment, with reason.

Author, year	**Reason for exclusion**
Altman, 2016 (48)	no cancer screening
Andrykowski, 2014 (49)	no cancer screening
Bagur et al., 2015 (50)	no cancer screening
Bergerot 2016 (51)	no cancer screening
Bergerot, 2018 (52)	no cancer screening
Bhattacharya, 2016 (53)	no cancer screening
Dauchy, 2013 (54)	no cancer screening
De la Cruz, 2014 (55)	no cancer screening
De la Garza, 2015 (56)	no cancer screening
Del Fabbro, 2015 (57)	no cancer screening
Dixon, 2017 (58)	no cancer screening
El-Zorkany, 2016 (59)	no cancer screening
Esser, 2018 (60)	no cancer screening
Fatiregun, 2016 (61)	no cancer screening
Goel, 2003 (62)	no cancer screening
Grassi, 2018 (63)	no cancer screening
Hahn, 2017 (64)	no cancer screening
Hallet, 2018 (65)	no cancer screening
Hartung, 2017 (66)	no cancer screening
Hirata, 2016 (67)	no cancer screening
Husson, 2015 (68)	no cancer screening
Ito, 2013 (69)	no cancer screening
Jones, 2014 (70)	no cancer screening
Kang, 2014 (71)	no cancer screening
Kim, 2019 (72)	No cancer screening
Kimmel, (73)	no cancer screening
Kisely, 2016(74)	no cancer screening
Klein, 2017 (75)	no cancer screening
Ko, 2018 (76)	no cancer screening
Konstantakopoulos, 2013 (77)	no cancer screening
Lemogne, 2012 (78)	no cancer screening
Li, 2016 (79)	no cancer screening
Lotfi-Jam, 2013 (80)	no cancer screening
Ma, 2013 (81)	no cancer screening
Malalur, 2016 (82)	no cancer screening
Maske, 2016 (83)	no cancer screening
Meiser, 2016 (84)	no cancer screening
Mertz 2017 (85)	no cancer screening
Meyer, 2015 (86)	no cancer screening
Millman, 2018 (87)	no cancer screening
Osório, 2015 (88)	no cancer screening
Pan, 2013 (89)	no cancer screening
Panagiotou, 2014 (90)	no cancer screening
Park, 2017 (91)	no cancer screening

Author, year	Reason for exclusion
Parrino, 2017 (92)	no cancer screening
Randhawa, 2017 (93)	no cancer screening
Recklitis, 2017 (94)	no cancer screening
Rhondali, 2014 (95)	no cancer screening
Rhondali, 2015 (96)	no cancer screening
Riedl, 2018 (97)	no cancer screening
Saracino, 2017 (98)	no cancer screening
Schaeffeler, 2018 (99)	no cancer screening
Schellekens, 2016 (100)	no cancer screening
Scherber, 2016 (101)	no cancer screening
Shimizu, 2012 (102)	no cancer screening
Shippee, 2017 (103)	no cancer screening
Sitaram, 2014 (104)	no cancer screening
Song, 2013 (105)	no cancer screening
Stadelmaier, 2017 (106)	no cancer screening
Trosman, 2017 (107)	no cancer screening
Tsai, 2014 (108)	no cancer screening
Underwood, 2015 (109)	no cancer screening
Valdes-Stauber, 2013 (110)	no cancer screening
Wagner, 2017 (111)	no cancer screening
Walming, 2018 (112)	no cancer screening
Watkins, 2015 (113)	no cancer screening
Xu, 2013 (114)	no cancer screening
Zhao, 2014 (115)	no cancer screening
Agay, 2017 (116)	no data available
Aggarwal, 2010 (117)	no data available
Andreassen, 2019 (118)	no data available
Baughman, 2016 (119)	no data available
Bires, 2016 (120)	no data available
Burke, 2017(121)	no data available
Caruso, 2012 (122)	no data available
Chen 2018 (123)	no data available
Fields, 2017 (124)	no data available
Gross, 2018 (125)	no data available
Halbert, 2016 (126)	no data available
Irwin, 2016 (127)	no data available
Kelly, 2014 (128)	no data available
Kronman, 2012 (129)	no data available
Lin, 2010 (130)	no data available
McLay, 2017 (131)	no data available
Montagna, 2019 (132)	no data available
Rashid, 2015 (133)	no data available
Sabia, 2016 (134)	no data available
Uemura, 2014 (135)	no data available
Kobayashi, 2018 (136)	no mental illness
Leiferman, 2006 (137)	no mental illness

Author, year	Reason for exclusion
Schwarz, 2003 (138)	no mental illness
Sullivan, 2003 (139)	no mental illness
Thorpe, 2006 (140)	no mental illness
Xiang, 2015 (141)	no mental illness
Constantinou, 2016 (142)	no valid diagnosis (self-report)
Kearns. 2018 (143)	no valid diagnosis (self-report)
Massetti, 2017 (144)	no valid diagnosis (self-report)
Rockson, 2016 (145)	no valid diagnosis (self-report)

References

1. Abrams MT, Myers CS, Feldman SM, Boddie-Willis C, Park J, McMahon RP, et al. Cervical cancer screening and acute care visits among Medicaid enrollees with mental and substance use disorders. Psychiatr Serv. 2012;63(8):815-22.
2. Aggarwal A, Freund K, Sato A, Adams-Campbell LL, Lopez AM, Lessin LS, et al. Are depressive symptoms associated with cancer screening and cancer stage at diagnosis among postmenopausal women? The Women's Health Initiative observational cohort. J Womens Health (Larchmt). 2008;17(8):1353-61.
3. Blackwell DL, Martinez ME, Gentleman JF. Women's compliance with public health guidelines for mammograms and pap tests in Canada and the United States: an analysis of data from the Joint Canada/United States Survey Of Health. Womens Health Issues. 2008;18(2):85-99.
4. Carney CP, Jones LE. The influence of type and severity of mental illness on receipt of screening mammography. J Gen Intern Med. 2006;21(10):1097-104.
5. Chochinov HM, Martens PJ, Prior HJ, Fransoo R, Burland E, Need To Know T. Does a diagnosis of schizophrenia reduce rates of mammography screening? A Manitoba population-based study. Schizophr Res. 2009;113(1):95-100.
6. Domino ME, Beadles CA, Lichstein JC, Farley JF, Morrissey JP, Ellis AR, et al. Heterogeneity in the quality of care for patients with multiple chronic conditions by psychiatric comorbidity. Med Care. 2014;52 Suppl 3:S101-9.
7. Druss BG, Rosenheck RA, Desai MM, Perlin JB. Quality of preventive medical care for patients with mental disorders. Med Care. 2002;40(2):129-36.
8. Druss BG, Rask K, Katon WJ. Major depression, depression treatment and quality of primary medical care. Gen Hosp Psychiatry. 2008;30(1):20-5.
9. Eriksson EM, Lau M, Jonsson C, Zhang C, Riso Bergerlind LL, Jonasson JM, et al. Participation in a Swedish cervical cancer screening program among women with psychiatric diagnoses: a population-based cohort study. BMC Public Health. 2019;19(1):313.
10. Folsom DP, McCahill M, Bartels SJ, Lindamer LA, Ganiats TG, Jeste DV. Medical comorbidity and receipt of medical care by older homeless people with schizophrenia or depression. Psychiatr Serv. 2002;53(11):1456-60.
11. Fujiwara M, Inagaki M, Nakaya N, Fujimori M, Higuchi Y, Hayashibara C, et al. Cancer screening participation in schizophrenic outpatients and the influence of their functional disability on the screening rate: A cross-sectional study in Japan. Psychiatry Clin Neurosci. 2017;71(12):813-25.
12. Inagaki M, Fujiwara M, Nakaya N, Fujimori M, Higuchi Y, Hayashibara C, et al. Low Cancer Screening Rates among Japanese People with Schizophrenia: A Cross-Sectional Study. Tohoku J Exp Med. 2018;244(3):209-18.
13. Gal G, Munitz H, Levav I. Lower risk of prostate cancer in schizophrenia: fact or artifact? The European Journal of Psychiatry. 2014;28:212-7.
14. Green CA, Pope CR. Depressive symptoms, health promotion, and health risk behaviors. Am J Health Promot. 2000;15(1):29-34.
15. Harder E, Juul KE, Jensen SM, Thomsen LT, Frederiksen K, Kjaer SK. Factors associated with non-participation in cervical cancer screening - A nationwide study of nearly half a million women in Denmark. Prev Med. 2018;111:94-100.
16. Holden AEC, Otto P, Gallion K, Ramirez AG. Abstract A45: Low English language facility, depression, and cancer screening among Latina breast cancer survivors. Cancer Epidemiology Biomarkers & Prevention. 2015;24(10 Supplement):A45.
17. Iezzoni LI, McCarthy EP, Davis RB, Harris-David L, O'Day B. Use of screening and preventive services among women with disabilities. Am J Med Qual. 2001;16(4):135-44.
18. Jensen LF, Pedersen AF, Bech BH, Andersen B, Vedsted P. Psychiatric morbidity and non-participation in breast cancer screening. Breast. 2016;25:38-44.
19. Kaida A, Colman I, Janssen PA. Recent Pap tests among Canadian women: is depression a barrier to cervical cancer screening? J Womens Health (Larchmt). 2008;17(7):1175-81.
20. Katz D, Tengekyon AJ, Kahan NR, Calderon-Margalit R. Patient and physician characteristics affect adherence to screening mammography: A population-based cohort study. PLoS One. 2018;13(3):e0194409.

21. Kempe KL, Larson RS, Shetterley S, Wilkinson A. Breast cancer screening in an insured population: whom are we missing? Perm J. 2013;17(1):38-44.
22. Koroukian SM, Bakaki PM, Golchin N, Tyler C, Loue S. Mental illness and use of screening mammography among Medicaid beneficiaries. Am J Prev Med. 2012;42(6):606-9.
23. Kotwal A, Mohile S, Dale W. A110: Depressive symptoms and high levels of stress significantly lower PSA screening rates in men with long life-expectancies in a nationally-representative sample. Journal of the American Geriatrics Society. 2012;60: S54.
24. Lasser KE, Zeytinoglu H, Miller E, Becker AE, Hermann RC, Bor DH. Do women who screen positive for mental disorders in primary care have lower mammography rates? Gen Hosp Psychiatry. 2003;25(3):214-6.
25. Lindamer LA, Buse DC, Auslander L, Unutzer J, Bartels SJ, Jeste DV. A comparison of gynecological variables and service use among older women with and without schizophrenia. Psychiatr Serv. 2003;54(6):902-4.
26. Lindamer LA, Wear E, Sadler GR. Mammography stages of change in middle-aged women with schizophrenia: an exploratory analysis. BMC Psychiatry. 2006;6:49.
27. Long H, Tulsky J, Chambers D, Alpers L, Robertson M, Moss A, et al. Cancer Screening in Homeless Women: Attitudes and Behaviors. Journal of Health Care for the Poor and Underserved 1998;9(3):276-92.
28. Ludman EJ, Ichikawa LE, Simon GE, Rohde P, Arterburn D, Operskalski BH, et al. Breast and cervical cancer screening specific effects of depression and obesity. Am J Prev Med. 2010;38(3):303-10.
29. Martens PJ, Chochinov HM, Prior HJ, Fransoo R, Burland E, Need To Know T. Are cervical cancer screening rates different for women with schizophrenia? A Manitoba population-based study. Schizophr Res. 2009;113(1):101-6.
30. Masterson EA, Hopenhayn C, Christian WJ. Self-reported mental health status and recent mammography screening. J Womens Health (Larchmt). 2010;19(8):1569-76.
31. Mo PK, Mak WW, Chong ES, Shen H, Cheung RY. The prevalence and factors for cancer screening behavior among people with severe mental illness in Hong Kong. PLoS One. 2014;9(9):e107237.
32. Olesen SC, Butterworth P, Jacomb P, Tait RJ. Personal factors influence use of cervical cancer screening services: epidemiological survey and linked administrative data address the limitations of previous research. BMC Health Serv Res. 2012;12:34.
33. Owen C, Jessie D, De Vries Robbe M. Barriers to cancer screening amongst women with mental health problems. Health Care Women Int. 2002;23(6-7):561-6.
34. Patten SB, Williams JV, Lavorato DH, Eliasziw M. The effect of major depression on participation in preventive health care activities. BMC Public Health. 2009;9:87.
35. Peytremann-Bridevaux I, Voellinger R, Santos-Eggimann B. Healthcare and preventive services utilization of elderly Europeans with depressive symptoms. J Affect Disord. 2008;105(1-3):247-52.
36. Pirraglia P, Sanyal P, Singer D, Ferris T. Depressive Symptom Burden as a Barrier to Screening for Breast and Cervical Cancers. Journal of Women's Health. 2004;13(6).
37. Salsberry PJ, Chipps E, Kennedy C. Use of general medical services among Medicaid patients with severe and persistent mental illness. Psychiatr Serv. 2005;56(4):458-62.
38. Stecker T, Fortney JC, Prajapati S. How depression influences the receipt of primary care services among women: a propensity score analysis. J Womens Health (Larchmt). 2007;16(2):198-205.
39. Thomas M, James M, Vittinghoff E, Creasman JM, Schillinger D, Mangurian C. Mammography Among Women With Severe Mental Illness: Exploring Disparities Through a Large Retrospective Cohort Study. Psychiatr Serv. 2018;69(1):48-54.
40. Tuesley KM, Jordan SJ, Siskind DJ, Kendall BJ, Kisely S. Colorectal, cervical and prostate cancer screening in Australians with severe mental illness: Retrospective nation-wide cohort study. Aust N Z J Psychiatry. 2018:4867418814945.
41. Vigod SN, Kurdyak PA, Stewart DE, Gnam WH, Goering PN. Depressive symptoms as a determinant of breast and cervical cancer screening in women: a population-based study in Ontario, Canada. Arch Womens Ment Health. 2011;14(2):159-68.
42. Werneke U, Horn O, Maryon-Davis A, Wessely S, Donnan S, McPherson K. Uptake of screening for breast cancer in patients with mental health problems. J Epidemiol Community Health. 2006;60(7):600-5.
43. Weitlauf JC, Jones S, Xu X, Finney JW, Moos RH, Sawaya GF, et al. Receipt of cervical cancer

screening in female veterans: impact of posttraumatic stress disorder and depression. Womens Health Issues. 2013;23(3):e153-9.
44. Woodhead C, Cunningham R, Ashworth M, Barley E, Stewart RJ, Henderson MJ. Cervical and breast cancer screening uptake among women with serious mental illness: a data linkage study. BMC Cancer. 2016;16(1):819.
45. Xiong GL, Bermudes RA, Torres SN, Hales RE. Use of cancer-screening services among persons with serious mental illness in Sacramento County. Psychiatr Serv. 2008;59(8):929-32.
46. Yee EF, White R, Lee SJ, Washington DL, Yano EM, Murata G, et al. Mental illness: is there an association with cancer screening among women veterans? Womens Health Issues. 2011;21(4 Suppl):S195-202.
47. Yen SM, Kung PT, Tsai WC. Mammography usage with relevant factors among women with mental disabilities in Taiwan: a nationwide population-based study. Res Dev Disabil. 2015;37:182-8.
48. Altman MR, Daratha KB. Abstracts from Research Forums Presented at the American College of Nurse-Midwives' 61st Annual Meeting. Journal of Midwifery & Women's Health. 2016;61(5):658-.
49. Andrykowski MA, Steffens RF, Bush HM, Tucker TC. Disparities in mental health outcomes among lung cancer survivors associated with ruralness of residence. Psychooncology. 2014;23(4):428-36.
50. Bagur J, Massoubre C, Casagranda L, Faure-Conter C, Trombert-Paviot B, Berger C. Psychiatric disorders in 130 survivors of childhood cancer: preliminary results of a semi-standardized interview. Pediatr Blood Cancer. 2015;62(5):847-53.
51. Bergerot CD, Philip EJ, Schuler TA, Clark KL, Loscalzo M, Buso MM, et al. Development and implementation of a comprehensive psychosocial screening program in a Brazilian cancer center. Psychooncology. 2016;25(11):1343-9.
52. Bergerot CD, Clark KL, Obenchain R, Philip EJ, Loscalzo M. Breast and gynecological cancer patients' risk factors associated with biopsychosocial problem-related distress. Psychooncology. 2018;27(3):1013-20.
53. Bhattacharya K, Noori W, Khanna R. Impact of Depression on Health-Related Quality of Life among Survivors of Skin Cancer. Value in Health. 2016;19(3):A160-A1.
54. Dauchy S, Dolbeault S, Reich M, Barruel F, Le Bihan A-S, Machavoine J-L. Depression in cancer patients: how to detect and manage it. PSYCHO-ONCOLOGIE. 2013;7(4):217-27.
55. De La C, II, Freund KM, Battaglia TA, Chen CA, Bak S, Kalish R, et al. Impact of depression on the intensity of patient navigation for women with abnormal cancer screenings. J Health Care Poor Underserved. 2014;25(1):383-95.
56. De La Garza R, Thekdi S, Rashid A, Lynn R, Ignatius J, Gonzalez R, et al. Characterization of Demographics and Psychiatric Symptoms in 500 Patients Enrolled in the M.D. Anderson Cancer Center Psychiatry Patient Registry Protocol: P1–112. Pscyho-Oncology. 2015;24:163, Jul.
57. Del Fabbro E, Jatoi A, Davis M, Fearon K, di Tomasso J, Vigano A. Health professionals' attitudes toward the detection and management of cancer-related anorexia-cachexia syndrome, and a proposal for standardized assessment. J Community Support Oncol. 2015;13(5):181-7.
58. Dixon B, Strzalka C, editors. Across the cancer continuum and lifespan: Patient reported outcome measures, quality of life, and mental health utilization. PSYCHO-ONCOLOGY; 2017: WILEY 111 RIVER ST, HOBOKEN 07030-5774, NJ USA.
59. El-Zorkany B, Mokbel A, Gamal SM, Mousa M, Youssef M, Hmamouchi I. Comparison of comorbidities of the Egyptian rheumatoid arthritis patients to the global cohort of the COMORA study: a post-hoc analysis. Clin Rheumatol. 2016;35(5):1153-9.
60. Esser P, Hartung TJ, Friedrich M, Johansen C, Wittchen HU, Faller H, et al. The Generalized Anxiety Disorder Screener (GAD-7) and the anxiety module of the Hospital and Depression Scale (HADS-A) as screening tools for generalized anxiety disorder among cancer patients. Psychooncology. 2018;27(6):1509-16.
61. Fatiregun OA, Olagunju AT, Erinfolami AR, Fatiregun OA, Arogunmati OA, Adeyemi JD. Anxiety disorders in breast cancer: Prevalence, types, and determinants. J Psychosoc Oncol. 2016;34(5):432-47.
62. Goel MS, Wee CC, McCarthy EP, Davis RB, Ngo-Metzger Q, Phillips RS. Racial and ethnic disparities in cancer screening the importance of foreign birth as a barrier to care. Journal of General Internal Medicine. 2003;18(12):1028-35.
63. Grassi L, Caruso R, Mitchell AJ, Sabato S, Nanni MG. Screening for emotional disorders in patients

with cancer using the Brief Symptom Inventory (BSI) and the BSI-18 versus a standardized psychiatric interview (the World Health Organization Composite International Diagnostic Interview). Cancer. 2018;124(11):2415-26.
64. Hahn C, Joo SH, Chae JH, Lee CU, Kim TS. Feasibility of Psychosocial Distress Screening and Management Program for Hospitalized Cancer Patients. Psychiatry Investig. 2017;14(6):734-45.
65. Hallet J, Isenberg-Grzeda E, Kazdan J, Beyfuss K, Myrehaug S, Singh S, et al., editors. Integrating Patient Reported Outcomes in Neuroendocrine Tumors Care: An Assessment of Cognitive and Psychological Screening Tools During Follow-up. ANNALS OF SURGICAL ONCOLOGY; 2018: SPRINGER 233 SPRING ST, NEW YORK, NY 10013 USA.
66. Hartung TJ, Friedrich M, Johansen C, Wittchen HU, Faller H, Koch U, et al. The Hospital Anxiety and Depression Scale (HADS) and the 9-item Patient Health Questionnaire (PHQ-9) as screening instruments for depression in patients with cancer. Cancer. 2017;123(21):4236-43.
67. Hirata S, Ovbiagele B, Markovic D, Towfighi A. Key Factors Associated with Major Depression in a National Sample of Stroke Survivors. J Stroke Cerebrovasc Dis. 2016;25(5):1090-5.
68. Husson O, Mols F, Fransen MP, van de Poll-Franse LV, Ezendam NP. Low subjective health literacy is associated with adverse health behaviors and worse health-related quality of life among colorectal cancer survivors: results from the profiles registry. Psychooncology. 2015;24(4):478-86.
69. Ito H, Fukuda K, Hattori H. [Depression in older adults: the National Mental Care Project for People with Physical Illness]. Nihon Ronen Igakkai Zasshi. 2013;50(6):740-3.
70. Jones G, Menon T, Vaidhyan C, Garchinski C, editors. Does the Distress Thermometer Measure and so Screen for Distress in Women With Breast Cancer? PSYCHO-ONCOLOGY; 2014: WILEY-BLACKWELL 111 RIVER ST, HOBOKEN 07030-5774, NJ USA.
71. Kang JI, Sung NY, Park SJ, Lee CG, Lee BO. The epidemiology of psychiatric disorders among women with breast cancer in South Korea: analysis of national registry data. Psychooncology. 2014;23(1):35-9.
72. Kim SW, Park WY, Jhon M, Kim M, Lee JY, Kim SY, et al. Physical Health Literacy and Health-related Behaviors in Patients with Psychosis. Clin Psychopharmacol Neurosci. 2019;17(2):279-87.
73. Kimmel M, Fairbairn M, Giuntoli R, 2nd, Jernigan A, Belozer A, Payne J, et al. The importance of social support for women with elevated anxiety undergoing care for gynecologic malignancies. Int J Gynecol Cancer. 2014;24(9):1700-8.
74. Kisely S, Forsyth S, Lawrence D. Why do psychiatric patients have higher cancer mortality rates when cancer incidence is the same or lower? Aust N Z J Psychiatry. 2016;50(3):254-63.
75. Klein J, Ludecke D, Hofreuter-Gatgens K, Fisch M, Graefen M, von dem Knesebeck O. Income and health-related quality of life among prostate cancer patients over a one-year period after radical prostatectomy: a linear mixed model analysis. Qual Life Res. 2017;26(9):2363-73.
76. Ko K-T, Lin C-J, Pi S-H, Li Y-C, Fang C-K. Demoralization Syndrome Among Elderly Patients with Cancer Disease. International Journal of Gerontology. 2018;12(1):12-6.
77. Konstantakopoulos G, Sofianopoulou E, Touloumi G, Ploumpidis D. [Ultra-short questionnaires for the detection of depression and anxiety]. Psychiatriki. 2013;24(4):288-97.
78. Lemogne C, Niedhammer I, Khlat M, Ravaud JF, Guillemin F, Consoli SM, et al. Gender differences in the association between depressive mood and mortality: A 12-year follow-up population-based study. Journal of Affective Disorders. 2012;136(3):267-75.
79. Li J, Eriksson M, Czene K, Hall P, Rodriguez-Wallberg KA. Common diseases as determinants of menopausal age. Human Reproduction. 2016;31(12):2856-64.
80. Lotfi-Jam K, Gough K, Schofield P, Aranda S. Profile and predictors of global distress: Can the DT guide nursing practice in prostate cancer? Palliative and Supportive Care. 2013;12(1):5-14.
81. Ma K-Z, Tang T-C, Chuang S-C, editors. The Effect of Psychiatric Care on Hepatocellular Carcinoma Patients with Subsequent Depression, Anxiety, and Sleep Disorders in Taiwan: Examining Hazard to Mortality and Accounting for Unobserved Heterogeneity. JOURNAL OF MENTAL HEALTH POLICY AND ECONOMICS; 2013: INT CTR MENTAL HEALTH POLICY & ECONOMICS-ICMPE VIA DANIELE CRESPI 7, MILANO ….
82. Malalur PG, Agastya M, Dawod Y, Phan L, Farooqui Mt, Yoo Jw. Cancer, depression, and health care coverage in the state of Nevada: A retrospective cross-sectional study. Journal of Clinical Oncology. 2016;34(7_suppl):42-.

83. Maske U, Maren J, Hapke U, Kleiber D, Busch MA. Diagnosed depression and utilization of healthcare and preventive services in the general adult population in Germany. European Psychiatry. 2016;33:S201-S2.
84. Meiser B, Quinn VF, Gleeson M, Kirk J, Tucker KM, Rahman B, et al. When knowledge of a heritable gene mutation comes out of the blue: treatment-focused genetic testing in women newly diagnosed with breast cancer. European Journal Of Human Genetics. 2016;24:1517.
85. Mertz BG, Dunn-Henriksen AK, Kroman N, Johansen C, Andersen KG, Andersson M, et al. The effects of individually tailored nurse navigation for patients with newly diagnosed breast cancer: a randomized pilot study. Acta Oncol. 2017;56(12):1682-9.
86. Meyer F, Fletcher K, Prigerson HG, Braun IM, Maciejewski PK. Advanced cancer as a risk for major depressive episodes. Psychooncology. 2015;24(9):1080-7.
87. Millman B, Kim R, O'Connor E, editors. Addressing the integrated primary care needs of cancer patients in Flint, Michigan. PSYCHO-ONCOLOGY; 2018: WILEY 111 RIVER ST, HOBOKEN 07030-5774, NJ USA.
88. Osorio FL, Lima MP, Chagas MH. Screening tools for psychiatry disorders in cancer setting: Caution when using. Psychiatry Res. 2015;229(3):739-42.
89. Pan X, Sambamoorthi U. Health Care Expenditures And Depression Among Adults With Cancer. Value in Health. 2013;16(3):A3.
90. Panagiotou I, Tsilika E, Parpa E, Patiraki E, Zygogianni A, Kouloulias V, et al. Locus of control and distressing symptoms in young cancer patients when assessing depression. J BUON. 2014;19(3):792-8.
91. Park SJ, Jang JW, Kim AY, Hong S, Yuk B, Min YW, et al. Association between Healthcare Utilization and Depression in Korean Women with Cardiovascular Conditions. Psychiatry Investig. 2017;14(6):801-7.
92. Parrino S, Sola M, Giulio B, Rosso A, Cinzia O, Alessandra G, et al., editors. Evaluating depression in elderly patients with cancer. ANNALS OF ONCOLOGY; 2017: OXFORD UNIV PRESS GREAT CLARENDON ST, OXFORD OX2 6DP, ENGLAND.
93. Randhawa GS, Ahern DK, Hesse BW. Information technology-enabled team-based, patient-centered care: The example of depression screening and management in cancer care. Health Policy Technol. 2017;6(1):67-71.
94. Recklitis C, Blackmon J, Chang G. Validity of the Brief Symptom Inventory-18 (BSI-18) for identifying depression and anxiety in young adult cancer survivors: Comparison with a Structured Clinical Diagnostic Interview. . Psychological Assessment
2017;29(10):1189-200.
95. Rhondali W, Chirac A, Celles L, Filbet M. [Depression and advanced cancer: agreement between different screening strategies]. Bull Cancer. 2014;101(2):137-43.
96. Rhondali W, Freyer G, Adam V, Filbet M, Derzelle M, Abgrall-Barbry G, et al. Agreement for depression diagnosis between DSM-IV-TR criteria, three validated scales, oncologist assessment, and psychiatric clinical interview in elderly patients with advanced ovarian cancer. Clin Interv Aging. 2015;10:1155-62.
97. Riedl D, Gastl R, Gamper E, Arnold CR, Dejaco D, Schoellmann F, et al. Cancer patients' wish for psychological support during outpatient radiation therapy : Findings from a psychooncological monitoring program in clinical routine. Strahlenther Onkol. 2018;194(7):655-63.
98. Saracino RM, Weinberger MI, Roth AJ, Hurria A, Nelson CJ. Assessing depression in a geriatric cancer population. Psychooncology. 2017;26(10):1484-90.
99. Schaeffeler N, Ringwald J, Wickert M, Zipfel S, Teufel M, Junne F, editors. Distress-screening in psycho-oncology: Towards a future screening gold-standard. ONCOLOGY RESEARCH AND TREATMENT; 2018: KARGER ALLSCHWILERSTRASSE 10, CH-4009 BASEL, SWITZERLAND.
100. Schellekens MPJ, van den Hurk DGM, Prins JB, Molema J, van der Drift MA, Speckens AEM. The suitability of the Hospital Anxiety and Depression Scale, Distress Thermometer and other instruments to screen for psychiatric disorders in both lung cancer patients and their partners. J Affect Disord. 2016;203:176-83.
101. Scherber R, Senyak Z, Kosiorek H, Dueck A, Clark M, Boxer M, et al. Treating Depression in the Myeloproliferative Neoplasms: The Role and Implications of Poorly Controlled Symptoms and Psychosocial Factors. Blood. 2016;128(22):5474.

102. Shimizu K, Nakaya N, Saito-Nakaya K, Akechi T, Yamada Y, Fujimori M, et al. Clinical biopsychosocial risk factors for depression in lung cancer patients: a comprehensive analysis using data from the Lung Cancer Database Project. Annals of Oncology. 2012;23(8):1973-9.
103. Shippee ND, Finch M, Wholey D. Using Statewide Data on Health Care Quality to Assess the Effect of a Patient-Centered Medical Home Initiative on Quality of Care. Popul Health Manag. 2018;21(2):148-54.
104. Sitaram B, Willam R, Dhruve N, Prapti I. Oncologists' proficiency in identifying psychological distress in cancer patients: Hits and misses. Journal of Clinical Oncology. 2014;32(15_suppl):e20572-e.
105. Song H, Li J, Lu Y, Deng L, Sun XL. Investigation of mental health and its influence on Chinese cancer patients using a multidisciplinary screening flow: An epidemiological survey in the west of China. Chinese Medical Journal. 2013;126(1):61-7.
106. Stadelmaier N, Gana K, Saada Y, Duguey-Cachey O, Quintard B. Psychometric Properties of the French Adaptation of the Basic Documentation for Psycho-Oncology (Po-Bado): A Distress Screening Tool. Behav Ther. 2017;48(5):596-602.
107. Trosman JR, Gerhart J, Patel U, Khosla P, Robinson PA, Penedo FJ, et al. Results of implementing a novel supportive oncology screening tool for comprehensive evaluation of distress and other supportive care needs. Journal of Clinical Oncology. 2017;35(15_suppl):e21644-e.
108. Tsai M, Dwyer M, Hamilton J. Effects of Depressive Symptoms and Distress on Psychosocial and Physical Factors in Pre-bone Marrow Transplant Patients: P1–71. scyho-Oncology. 2014;23:102.
109. Underwood JA, McDonald E, Higginbotham K, Korber SF. Addressing psychiatric needs in an adult comprehensive cancer center. Journal of Clinical Oncology. 2015;33(29_suppl):218-.
110. Valdes-Stauber J, Vietz E, Kilian R. The impact of clinical conditions and social factors on the psychological distress of cancer patients: an explorative study at a consultation and liaison service in a rural general hospital. BMC Psychiatry. 2013;13:226.
111. Wagner LI, Pugh SL, Small W, Jr., Kirshner J, Sidhu K, Bury MJ, et al. Screening for depression in cancer patients receiving radiotherapy: Feasibility and identification of effective tools in the NRG Oncology RTOG 0841 trial. Cancer. 2017;123(3):485-93.
112. Walming S, Block M, Bock D, Angenete E. Timely access to care in the treatment of rectal cancer and the effect on quality of life. Colorectal Dis. 2018;20(2):126-33.
113. Watkins DC, Assari S, Johnson-Lawrence V. Race and Ethnic Group Differences in Comorbid Major Depressive Disorder, Generalized Anxiety Disorder, and Chronic Medical Conditions. J Racial Ethn Health Disparities. 2015;2(3):385-94.
114. Xu Y, Owen J, Thornton A, Stanton A. Predictors of Depression in Patients With Lung Cancer: P2-84. Psycho-Oncology. 2013;22:145.
115. Zhao L, Li X, Zhang Z, Song C, Guo C, Zhang Y, et al. Prevalence, correlates and recognition of depression in Chinese inpatients with cancer. Gen Hosp Psychiatry. 2014;36(5):477-82.
116. Agay N, Flaks-Manov N, Nitzan U, Hoshen MB, Levkovitz Y, Munitz H. Cancer prevalence in Israeli men and women with schizophrenia. Psychiatry Res. 2017;258:262-7.
117. Aggarwal A, Nien-Chen L, Kazis L, Lee A, Berlowitz D, editors. Predictors associated with low colorectal cancer screening rates in patients with chronic mental illnesses and substance use disorders: a nation-wide data analysis. JOURNAL OF GENERAL INTERNAL MEDICINE; 2010: SPRINGER 233 SPRING ST, NEW YORK, NY 10013 USA.
118. Andreassen T, Hansen BT, Engesaeter B, Hashim D, Stoer NC, Trope A, et al. Psychological effect of cervical cancer screening when changing primary screening method from cytology to high-risk human papilloma virus testing. Int J Cancer. 2019;145(1):29-39.
119. Baughman AW, Li Z, Friedberg MW, Singer S, Schneider E, Bates DW, et al., editors. Impact of the patient-centered medical home on patients with depression. JOURNAL OF GENERAL INTERNAL MEDICINE; 2016: SPRINGER 233 SPRING ST, NEW YORK, NY 10013 USA.
120. Bires J, Blair L, editors. Collaboration Between Psychiatry and Social Work at a Teaching Institution to Ensure Better Access to Psychiatric Services for Oncology Patients. JOURNAL OF PSYCHOSOCIAL ONCOLOGY; 2016: ROUTLEDGE JOURNALS, TAYLOR & FRANCIS LTD 4 PARK SQUARE, MILTON PARK ….
121. Burke H, Russo CA, Hopkins L, Jeffery DD. Comparing patients with breast and prostate cancer in terms of their mental health comorbidities as predictors of cost and utilization. Journal of Clinical Oncology. 2017;35(8_suppl):18-.

122. Caruso R, Morelli AC, Nanni MG, Biancosino B, Grassi L. Psychiatric Disorders Related to Cancer: Prevalence, Etiology, and Recognition. 2012;1(1):7-39.
123. Chen LY, Hung YN, Chen YY, Yang SY, Pan CH, Chen CC, et al. Cancer incidence in young and middle-aged people with schizophrenia: nationwide cohort study in Taiwan, 2000-2010. Epidemiol Psychiatr Sci. 2018;27(2):146-56.
124. Fields L, Corveleyn A, Pirl W, Park E, Greer J, Kotagiri N, et al., editors. Tailoring research design for patients with severe mental illness and cancer. PSYCHO-ONCOLOGY; 2017: WILEY 111 RIVER ST, HOBOKEN 07030-5774, NJ USA.
125. Gross S, Kowalski C, Ansmann L, Pfaff H, Gross-Kunkel A, editors. Health Care of Breast Cancer Patients With Disabilties. ONCOLOGY RESEARCH AND TREATMENT; 2018: KARGER ALLSCHWILERSTRASSE 10, CH-4009 BASEL, SWITZERLAND.
126. Halbert B, Davis RB, Wee CC, editors. HOW DOES DEPRESSION AFFECT THE UTILIZATION OF HIGH- AND LOW-VALUE CARE? JOURNAL OF GENERAL INTERNAL MEDICINE; 2016: SPRINGER 233 SPRING ST, NEW YORK, NY 10013 USA.
127. Irwin K, Meshesha M, Henderson D, Pirl W, Park E. Schizophrenia and Lung Cancer Disparities: Communication with Psychiatrists and Primary Care Physicians Regarding Smoking and Lung Cancer Risk: P2-60. Pscyho-Oncology. 2016;25:152.
128. Irwin K, editor Breast Cancer and Schizophrenia: Disparities in Outcomes and Opportunities for Improvement. PSYCHO-ONCOLOGY; 2014: WILEY-BLACKWELL 111 RIVER ST, HOBOKEN 07030-5774, NJ USA.
129. Kronman AC, Freund KM, Heeren T, Beaver KA, Flynn M, Battaglia TA. Depression and anxiety diagnoses are not associated with delayed resolution of abnormal mammograms and pap tests among vulnerable women. J Gen Intern Med. 2012;27(4):452-7.
130. Lin H, Yang L, Chiu W. Cervical cancer screening of women with schizophrenia in Taiwan. Psychiatric Services. 2010;61(3):327-8.
131. McLay M, Olson R, Callaghan R. Assessing the Hazard of Tobacco-Related Cancers Among Individuals With Psychiatric Disorders in British Columbia. International Journal of Radiation Oncology• Biology• Physics. 2017;99(2):E408-E9.
132. Montagna G, Schneeberger AR, Rossi L, Reina H, Schwab FD, Schoetzau A, et al. The impact of depression on adherence to organized and opportunistic breast cancer screening. Eur J Cancer Prev. 2019.
133. Rashid A, De La Garza R, Joseph N, Sea A, Valentine A. Correlations of High Edmonton Symptom Assessment Scale Scores to Demographic and Other Variables: P1–122. Pscyho-Oncology. 2015;24:168-9.
134. Sabia A, Anger WH, Jr. Interventions to Encourage Uptake of Cancer Screening for People With Severe Mental Illness. Issues Ment Health Nurs. 2016;37(7):533.
135. Uemura K, editor Disadvantage in Care that People with Severe Mental Illness Encounter in General Hospital Settings. PSYCHO-ONCOLOGY; 2014: WILEY-BLACKWELL 111 RIVER ST, HOBOKEN 07030-5774, NJ USA.
136. Kobayashi M, Kawachi H, Pasternak S, Delgado C, Pinto P, Ito T, et al. Histopathologic study from a colorectal cancer screening in Chile: results from the first 2 years of an international collaboration between Chile and Japan. Eur J Cancer Prev. 2018.
137. Leiferman JA, Pheley AM. The effect of mental distress on women's preventive health behaviors. Am J Health Promot. 2006;20(3):196-9.
138. Schwartz M, Taylor K, Willard K. Prospective association between distress and mammography utilization among women with a family history of breast cancer. Journal of Behavioral Medicine. 2003;26(2):105-17.
139. Sullivan SG, Glasson EJ, Hussain R, Petterson BA, Slack-Smith LM, Montgomery PD, et al. Breast cancer and the uptake of mammography screening services by women with intellectual disabilities. Prev Med. 2003;37(5):507-12.
140. Thorpe JM, Kalinowski CT, Patterson ME, Sleath BL. Psychological distress as a barrier to preventive care in community-dwelling elderly in the United States. Med Care. 2006;44(2):187-91.
141. Xiang X. Serious psychological distress as a barrier to cancer screening among women. Womens Health Issues. 2015;25(1):49-55.
142. Constantinou P, Dray-Spira R, Menvielle G. Cervical and breast cancer screening participation for

women with chronic conditions in France: results from a national health survey. BMC Cancer. 2016;16:255.
143. Kearns B, Chilcott J, Relton C, Whyte S, Woods HB, Nickerson C, et al. The association between long-term conditions and uptake of population-based screening for colorectal cancer: results from two English cohort studies. Cancer Manag Res. 2018;10:637-45.
144. Massetti GM, Thomas CC, King J, Ragan K, Buchanan Lunsford N. Mental Health Problems and Cancer Risk Factors Among Young Adults. American Journal of Preventive Medicine. 2017;53(3, Supplement 1):S30-S9.
145. Rockson LE, Swarbrick MA, Pratt C. Cancer Screening Among Peer-Led Community Wellness Center Enrollees. J Psychosoc Nurs Ment Health Serv. 2016;54(3):36-40.

Country/region and Mental illness	Cancer	Publications/samples	Prevalence	Heterogeneity	Subgroup comparison between schizophrenia and mood disorders
Schizophrenia spectrum disorders	Colorectal cancer	3/3	27.4% (17.3-40.4)	79.04%	
Prostate cancer					
Any mental illness	Prostate cancer	5/11	48.2% (31.3-65.5)	99.56%	
Asia	Prostate cancer	1 /1	20.8% (16.1-26.4)	NA	<0.001
Israel	Prostate cancer	1/1	26.2% (25.3-27.1)	NA	
USA	Prostate cancer	3/9	54.9% (42-67.2)	98.24%	
Mood disorders	Prostate cancer	1/2	49.4% (35.5-63.6)	NA	<0.001
Schizophrenia spectrum disorders	Prostate cancer	1/1	26.2% (25.3-27.1)	NA	

Country/region	Publications/samples	OR (95%CI)*	p value	I^2	Subgroup difference across different regions p value
Cervical cancer					
USA	3/5	1.015(0.707-1.457)	0.935	97.66%	0.089
Canada	1 / 1	0.700(0.652-0.752)	<0.001	NA	
Europe	3/4	0.562(0.351-0.899)	0.016	99.08%	
Mood disorders					
Any cancer					
Europe	5/7	0.948(0.875-1.028)	0.195	88.47%	0.012
USA*	15/33	0.850(0.752-0.962)	0.010	99.13%	
Israel	1 / 1	0.767(0.691-0.851)	<0.001	NA	
Canada*	4/7	0.761(0.510-1.136)	0.181	85.70%	
Australia	1 / 1	0.630(0.419-0.947)	0.026	NA	
Breast cancer					
Canada*	3/3	1.205(0.594-2.447)	0.605	40.22%	0.215
Europe	3/3	0.862(0.766-0.969)	0.013	27.88%	
Israel	1 / 1	0.767(0.691-0.851)	<0.001	NA	
USA*	12/17	0.733(0.618-0.869)	<0.001	98.57%	
Cervical cancer					
Europe	3/3	0.964(0.904-1.028)	0.266	81.24%	0.079
USA*	8/11	0.943(0.794-1.120)	0.505	97.81%	
Australia	1 / 1	0.630(0.419-0.947)	0.026	NA	
Canada*	4/4	0.629(0.385-1.028)	0.065	92.06%	
Colorectal cancer					
Europe	1 / 1	1.300(1.095-1.543)	0.003	NA	0.354
USA	4/4	1.157(0.970-1.381)	0.106	97.50%	

#USA and Canada have been considered separately given the difference in health-care system

* Blackwell[1] provided data from both Canada and USA

References

1. Blackwell DL, Martinez ME, Gentleman JF. Women's compliance with public health guidelines for mammograms and pap tests in Canada and the United States: an analysis of data from the Joint Canada/United States Survey Of Health. *Womens Health Issues.* 2008;18(2):85-99.

Cancer screening	Publications/samples	OR (95%CI)*	p value	I^2	Egger's test p value / Fail safe N / Effect size after trim and fill (in case of publication bias)
Any	25/49	0.851 (0.783-0.926)	<0.001	98.84%	0.639 / 4224
Breast	18/24	0.770 (0.668-0.886)	<0.001	98.09%	0.198 / 3838
Cervical	16/19	0.93 (0.856-1.011)	0.094	96.84%	0.776 / NA
Colorectal	5/5	1.181 (1.011-1.381)	0.036	96.70%	0.820 / 148
DSM or ICD diagnosis					
Any	9/15	0.966 (0.866-1.077)	0.534	96.87%	0.935 / NA
Breast	4/6	0.658 (0.475-0.911)	0.012	96.11%	0.232 / 172
Cervical	7/8	1.138 (1.000-1.294)	0.05	97.068%	0.174 / NA
Adjusted studies*					
Any	20/39	0.87 (0.816-0.928)	<0.001	95.13%	0.126 / 1240
Breast	14/20	0.799 (0.732-0.873)	<0.001	88.90%	0.521 / 817
Cervical	13/16	0.911 (0.82-1.011)	0.08	96.25%	0.802 / NA
Colorectal	2/2	1.075 (0.751-1.539)	0.694	92.48%	NA

NA, not applicable; #Any psychiatric disorders include schizophrenia spectrum disorders, mood disorders, substance abuse, adjustment disorders, somatoform disorders, eating disorders, anxiety disorders, sexual disorders, sleep disorders, post-traumatic stress disorder. studies adjusted for age, behavioral risk, body dissatisfaction, body mass index, comorbidity, country of origin, educational level, employment status, ethnicity, health-services use, insurance status, marital status, number of inpatient episodes, region, smoking status, social deprivation, socio-economic status, type of mental disorder, urbanicity.*